




Russian River Estuary Sandbar Breaching

2005 Monitoring Report

SONOMA COUNTY WATER AGENCY

July 2006

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Executive Summary

The Russian River estuary (Estuary) closes throughout the year as a result of a sandbar forming at the mouth of the Russian River. Closures result in ponding of the Russian River behind the sandbar and increased water levels in the Estuary. The Sonoma County Water Agency (Agency) mechanically breaches the sandbar to alleviate potential flooding of low-lying shoreline properties near the town of Jenner.

Breaching the sandbar requires permits from state and federal regulatory agencies, including the U.S. Army Corps of Engineers (Corps) and the National Marine Fisheries Service (NMFS). Three federally-listed salmonids are found in the Russian River watershed: central California coast steelhead (*Oncorhynchus mykiss*), California coastal Chinook salmon (*O. tshawytscha*), and central California coast coho salmon (*O. kisutch*). The Russian River estuary is important for adult and juvenile passage for the listed salmonids (ENTRIX, Inc. 2001). The Estuary provides an opportunity for smolts to acclimate to ocean conditions before migrating to the ocean, as well as potentially providing rearing habitat for steelhead and Chinook salmon. The Corps and NMFS required the Agency to develop and implement an estuary monitoring plan that included documenting salmonid presence in the Estuary (National Marine Fisheries Service, Southwest Region 2005).

The goals of the Russian River Estuary Sandbar Breaching Monitoring Plan (Martini-Lamb et al. 2005) are to: document the distribution, abundance, and condition of listed salmonids in the Russian River estuary; document salmonid residence times in the Estuary; and to assess the habitat parameters that affect salmonid presence and distribution in the Estuary. In 2005, the Agency monitored water quality and fisheries, including implementing a juvenile steelhead residency pilot study, to meet the plan's goals. These variables provide information on the suitability of water quality for salmonids and document the distribution and timing of salmonid use of estuarine habitats during the period of most frequent sandbar closure. This annual report provides the results of the first of five years of monitoring.

Breaching Events in 2005

There were four sandbar closures and breaching events in 2005. They occurred in the late summer and fall months, which is typical for the Russian River estuary. This is a period of generally lower instream flows and increased sand transport onto the sandbar. The lack of a late spring or early summer closure was somewhat unusual; spring and summer closures occurred from 1996 to 2004, with the exception of 1998. Late spring rains in 2005 and the resulting higher river flows probably prevented the sandbar from forming. The number and timing of sandbar closures and breaching events in 2005 was similar to the events from 1996 to 2004.

Water Quality

Water quality was monitored in the lower estuary between Bridgehaven and the mouth of the river. Data was collected to establish baseline information and gain a better understanding of the longitudinal and vertical water quality profile during the ebb and flow of the tide, as well as to track changes that may occur during periods of sandbar closure and reopening. Three

stations were established for water quality monitoring: the mouth of the Russian River at Goat Rock State Beach (Mouth station); Penny Island near the Jenner boat ramp (Penny Island station); and just downstream from the Highway 1 bridge at Bridgehaven (Bridgehaven station).

Water quality conditions in 2005 were similar to those recorded in 2004. The lower and middle reaches of the Estuary are predominantly saline environments with a thin freshwater layer that flows over the denser saltwater. Dissolved oxygen (D.O.) concentrations fluctuated significantly during the monitoring season at all stations. These fluctuations were not necessarily associated with tidal cycles nor were they on a diurnal cycle. Supersaturation and anoxic events were observed, with prolonged anoxic events occurring at the bottom sondes through the duration of estuary closure. However, D.O. concentrations at the surface sondes did not appear to be negatively impacted by estuary closure and either remained similar to pre-closure conditions or increased in some instances. The Penny Island and Bridgehaven mid-depth sondes also recorded decreasing D.O. concentrations during estuary closure.

Temporary decreases in salinity concentrations occurred at most sondes during estuary closure and following sandbar breaching events. Once the river had been reopened, the downstream movement of the salt wedge was likely attributable to the initial flush of water out of the Estuary. However, this flush was temporary and salinity concentrations typically recovered to pre-closure levels as the salt wedge migrated back upstream during subsequent high tides. Temperature stratification coincided with the presence of the salt wedge, as the saltwater was observed to be significantly colder than the freshwater. Mean and maximum water temperatures at all 3 stations were typically lower at the bottom and mid-depth sondes, which were located primarily in saltwater. Surface sonde temperatures had the greatest degree of fluctuation due to their location at the saltwater-freshwater interface. However, temperatures were also observed to exhibit diel fluctuations based on the heating and cooling effects of night and day, as well as longer-term seasonal heating and cooling events.

Fisheries

The Estuary fisheries monitoring area consisted of the tidally-influenced section of the Russian River from the sandbar at the Pacific Ocean to the confluence with Austin Creek. Eight seining stations were located throughout the Estuary at: River Mouth; Penny Island; Jenner Gulch; Patty Rock; Willow Creek; Sheephouse Creek; Heron Rookery; and Austin Creek.

A total of 8,440 fish from 20 species were recorded in the Estuary during 2005. The distribution of species was influenced by the salinity gradient in the Estuary that is typically seawater near the mouth of the Russian River and freshwater at the upstream end. Exceptions to this distribution pattern were anadromous fish that occurred throughout the Estuary regardless of salinity levels. In 2005, 438 steelhead and 105 Chinook salmon were captured. Chinook salmon smolts were distributed throughout the Estuary with captures at every sample station. The highest capture in 2005 was at the Patty Rock station with 37 fish seined on the same day. Steelhead distribution was primarily in the middle and upper reaches of the Estuary, although relatively large numbers were captured at the Jenner Gulch station. The Austin Creek station consistently had the highest abundance of steelhead. Austin Creek station is entirely freshwater and is not characteristic of conditions in the Russian River estuary. The abundance of Chinook salmon peaked during early June and none were captured after July. Steelhead were captured throughout summer (their numbers peaked in mid-July).

Macro-invertebrates

The Agency surveyed macro-invertebrates in the Estuary in 2004 and 2005. Although breaching permits do not require this monitoring, the survey results are presented in this report. The purpose of the surveys is to determine the relative abundance and distribution of macro-invertebrates in the Estuary. Six permanent trap stations were distributed between the Russian River mouth and 6.4 km (4.0 mi) upstream.

In 2005, 26 Dungeness crabs (*Cancer magister*), 3 European green crabs (*Carcinus maenus*), and 1 hairy rock crab (*Cancer jordani*) were captured. Adult Dungeness crabs were captured in August and September. In contrast, 45 adults were trapped from May to September in 2004. Although adults were absent in spring and early summer 2005, their numbers were similar during both study years in August and September. The 2004 data indicated that the Estuary is a nursery for juvenile Dungeness crabs; however, no juveniles were caught in 2005. This may be a result of atypical winter ocean temperatures and currents in 2005. These conditions probably affected larval Dungeness crab survival and migration to inshore areas and estuaries.

The European green crab is non-native species that was first introduced to the San Francisco Bay in the 1980s and has since invaded other Pacific Coast estuaries. This crab has decimated fisheries on the east coast. The capture of 3 individuals in 2005 is the first known occurrence in the Estuary and it may become established with unknown consequences to the native fishery. Further studies of the abundance and distribution of this species in the Estuary would be helpful in managing this species.

Juvenile Steelhead Residency Pilot Study

The first year of a two-year pilot study was implemented to evaluate the effectiveness of using acoustic telemetry and passive integrated transponder (PIT) tags to monitor juvenile steelhead summer residency in the Estuary. The purpose of the study is to determine the distribution and residence times of juvenile steelhead within the Estuary and to gain an understanding of how sandbar and water quality conditions may influence their presence and behavior (Fuller and Manning 2005).

Steelhead with surgically implanted acoustic transmitters were tracked from the river's mouth upstream to Austin Creek. To monitor tagged fish passage, three fixed hydrophone-receiving stations were placed in the upper, middle, and lower reaches of the Estuary near Duncans Mills bridge, Sheephouse Creek, and downstream of Penny Island. The submerged hydrophones were staggered up and down stream in an attempt to determine the direction fish were moving. To generate more detailed information about fish movement, we supplemented data from the fixed stations with manual tracking. Weekly tracking surveys were conducted from the river mouth to Brown's Riffle during ebb and flood tide. To gain information on residence time, growth rate, and habitat use of juvenile steelhead at the Austin Creek site, we tagged 100 fish with passive integrated transponder (PIT) tags from mid-June to early August.

Thirty-nine of forty-two juvenile steelhead were captured, tagged, and released. The mean length and weight of tagged fish was 188 mm and 94 g. Twenty-eight of thirty-nine tagged fish were detected at least once after release by the fixed stations or manual tracking. Five of the eleven tagged fish that were never detected were tagged at Austin Creek.

One hundred juvenile steelhead were PIT-tagged at the mouth of Austin Creek. Recapture efforts persisted until early October 2005. Five fish were recaptured within two weeks of initial capture and had a mean length and weight of 128 mm and 27 g. No measurable growth had occurred.

We successfully tracked fish for over 100 days and gained insight to juvenile steelhead utilization of the Russian River estuary. We gained less information about smaller fish (<60 g) than larger fish (>60 g) because short-term mortality was higher, movement was less frequent, and tracking durations were shorter. We believe the behavior of smaller fish was affected by the size and weight of the transmitters. The stress of capture, handling, and implantation of a relatively large transmitter may have increased the susceptibility of these smaller fish to predators.

The area between Jenner Gulch and Sheephouse Creek was highly utilized during the early part of the study. Schooling by tagged fish was observed below Patty Rock on multiple occasions. As the season progressed, we expected most fish to emigrate to the ocean. Some evidence suggests that this occurred, but only 28% of the fish were last detected at the mouth receiver. While movement between Jenner Gulch and Sheephouse Creek was common, fewer fish were detected in the 5-km reach from Sheephouse Creek to Duncan's Mills. We plan to conduct more frequent mobile tracking and collect additional water quality data in 2006 to elucidate patterns of fish behavior in the upper estuary.

Changes to Monitoring Plan

We plan to institute changes to the Russian River Estuary Sandbar Breaching Monitoring Plan to improve assessment of habitat parameters that affect salmonid use of the Estuary. The changes do not significantly alter previous methods used; we anticipate that these changes will refine our monitoring methods to detect trends of salmonid behavior in the Estuary. The changes include two new water quality monitoring stations, adding more intensive seining efforts and exploratory fisheries survey methods to the interval fish seining, using a combination of smaller and larger acoustic tags for the juvenile steelhead residency pilot study, and more frequent tracking of tagged steelhead.

Introduction

The Russian River estuary (Estuary) is located 97 km (60 mi) northwest of San Francisco in Jenner, Sonoma County, California (Figure 1). The Russian River watershed encompasses 3,847 km^2 (1,485 square mi) in Sonoma, Mendocino, and Lake counties. The 11-km-long (7-mi-long) estuary extends from the mouth of the Russian River upstream to the community of Duncans Mills. The Estuary is constrained by narrow valley walls in the lower reach of the Russian River. Coastal and valley freshwater marsh, non-native annual grasslands, and north coast riparian scrub are the dominant terrestrial habitats in the Estuary. The valley walls are vegetated by coastal terrace prairie and redwood and Douglas fir forests (Heckel 1994).

The Estuary closes throughout the year as a result of a sandbar forming at the mouth of the Russian River. The sandbar closes most often in the spring, summer, and fall when river flows are relatively low and long period waves transport sand landward, rebuilding the beach that was removed by winter waves and river outflows (Heckel 1994). Closures result in ponding of the Russian River behind the sandbar and increased water levels in the Estuary. Natural breaching events occur when estuary water surface levels exceed the sandbar height and overtop it, scouring an outlet channel. The Sonoma County Water Agency (Agency) mechanically breaches the sandbar to alleviate potential flooding of low-lying shoreline properties near the town of Jenner. Breaching is performed in accordance with the Russian River Estuary Management Plan outlined in the *Russian River Estuary Study 1992-1993* (Heckel 1994). The management plan specifies breaching the sandbar when the estuary water surface level is between 1.4 and 2 meters (m; 4.5 and 7.0 feet) as read at the Jenner gage.

Conditions in the Russian River estuary are generally similar to “typical” estuarine environments. Salinity steadily increases from the freshwater/estuary interface with low salinity (0-5 ppt), to moderate salinity in the middle reach (approximately 15 ppt), to the highly saline tidal zone near the ocean (30-35 ppt) (Day et al 1989). Salinity also increases with depth. Saline water is denser than freshwater and a salinity “wedge” forms as freshwater outflow passes over the denser tidal inflow. River flows, tides, and wind action affect the amount of mixing at various longitudinal and vertical positions within the Estuary. In most estuaries, including the Russian River estuary, water stratification is common in deeper sections of the estuary or when vertical mixing is limited.

Stratification was evident during biological and water quality monitoring of breaching events from 1996 to 2000. Near-bottom layers of the Estuary water column often became anoxic and highly saline within a few days of sandbar closure. Similar conditions were also observed when the sandbar was open during neap tides or low-river flows. Once the Estuary is breached, it may take more than one tidal cycle for dissolved oxygen (D.O.) levels in the near-bottom layers to increase in the upper reach of the Estuary. Breaching the sandbar improves water quality conditions in the Estuary and restores pre-closure conditions. The maximum breaching water surface elevation of 2 m (7 ft) was recommended in the management plan to: avoid discharge of anoxic water from Willow Creek marsh into the

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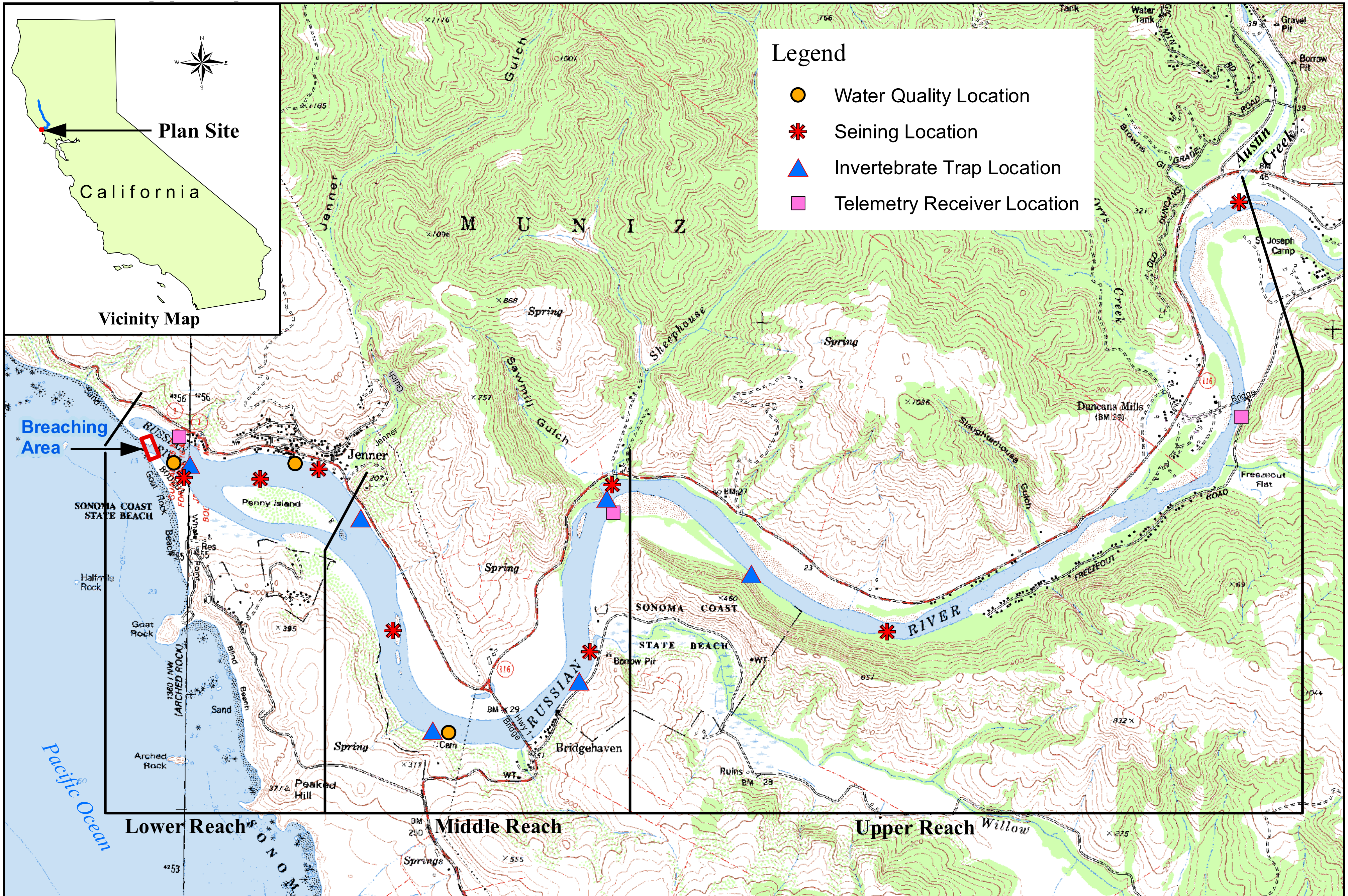


0 0.2 0.4 0.8 Kilometers

0 0.2 0.4 0.8 Miles

Russian River Estuary
Sandbar Breaching Monitoring - 2005

This Map is for general reference only.

Figure 1

Estuary; minimize flooding of property; reduce high flushing velocities caused by high surface water levels in the Estuary; and minimize the danger posed by high velocity flows to beach visitors and breaching crews during and immediately following breaching. Breaching the Estuary at levels greater than 2.4 m (8.0 ft) floods the Willow Creek marsh, which becomes anoxic during summer months due to low water inflow and high biochemical oxygen demand, and results in the subsequent draining of the poor water quality into the Estuary (Sonoma County Water Agency and Merritt Smith Consulting 2001). Draining of the marsh previously resulted in a series of fish and macro-invertebrate mortalities at the confluence of Willow Creek and the Estuary.

The Agency also monitored pinnipeds, macro-invertebrates, and fish during breaching events from 1996 to 2000. Forty-seven fish species were observed in the Russian River estuary during the 5 years of monitoring (Sonoma County Water Agency and Merritt Smith Consulting 2001). Results indicated that fish species diversity and abundance was driven more by seasonal variability than by sandbar conditions (open versus closed). Estuarine fishes were more abundant during spring and summer months when they entered the Estuary to spawn and rear. Species diversity and abundance declined during the fall months, possibly due to unfavorable thermal conditions (Merritt Smith Consulting 2000).

Three federally-listed salmonids are found in the Russian River watershed: central California coast steelhead (*Oncorhynchus mykiss*), California coastal Chinook salmon (*O. tshawytscha*), and central California coast coho salmon (*O. kisutch*). The Russian River estuary is important for adult and juvenile passage for the listed salmonids (ENTRIX, Inc. 2001). The Estuary provides an opportunity for smolts to acclimate to ocean conditions before migrating to the ocean, as well as potentially providing rearing habitat for steelhead and Chinook salmon. Steelhead were captured in the Estuary during each of the five monitoring years. Chinook salmon were captured in two of the five monitoring years.

Breaching Activities

Breaching occurs on the closed sandbar. The sandbar is accessed from the paved parking lot at Goat Rock State Beach, located at the end of Goat Rock Road off of Highway 1 (Figure 1). Equipment is off-loaded in the parking lot and driven onto the beach via an existing access point. A bulldozer or similar equipment is used to breach the sandbar. The Agency used an excavator to breach the sandbar during each of the 2005 closure events. Using an excavator allowed the operator to remove sand and place it on the beach without entering the pilot channel.

A cut in the sandbar is created at a sufficient depth to allow river flows to begin transporting sand to the ocean. The sand is placed onto the beach adjacent to the pilot channel. After the pilot channel is excavated, the last upstream portion of the sandbar is removed, allowing river water to flow to the ocean. The size of the pilot channel varies depending on the height of the sandbar to be breached, the tide level, and the water surface level in the Estuary. A typical channel is approximately 30 m long, 8 m wide, and 2 m deep (100 ft long, 25 ft wide, and 6 ft deep). The amount of sand moved can range from less than 100 cubic yards to approximately 1,000 cubic yards. The Agency notifies California Department of Parks and

Recreation (State Parks) lifeguards within 24 hours prior to breaching activities to minimize potential hazards to beach visitors. Signs and barriers are posted for 24 hours prior to and after breaching events to warn beach visitors of the hazards of the breaching area.

There were four sandbar closures and breaching events in 2005 (Table 1). The cluster of events during the late summer and fall months is typical for the Russian River estuary. This is a period of generally lower instream flows and increased sand transport onto the sandbar. The lack of a late spring or early summer closure was somewhat unusual; spring and summer closures occurred from 1996 to 2004, with the exception of 1998. Late spring rains and the resulting higher river flows probably prevented the sandbar from forming.

Table 1. Russian River estuary 2005 sandbar closures and breaching events.

Approximate Sandbar Closure Date	Approx. No. of Days Closed	Breaching Event Date	Jenner Gage Level at Breach (feet)
09/16/2005	6	09/22/2005	6.0
10/03/2005	14	10/17/2005[a]	8.3
10/25/2005	6	11/01/2005	8.0
11/25/2005	4	11/29/2005	8.2

[a] The Agency breached the sandbar on 10/11/2005 and 10/13/2005, but the sandbar closed within hours without a change in water surface levels at the Jenner gage. Therefore, this event is treated as a single closure.

The number and timing of sandbar closures and breaching events in 2005 was similar to the events from 1996 to 2004 (a low of 3 breaching events in 2003 to a high of 11 breaching events in 2000). Water surface levels in the Estuary surpassed the 7 ft breaching height during 3 closures in October and November (Table 1). The 3 October 2005 closure required the Agency to make three breaching attempts. The sandbar was breached on 11 October and 13 October, but closed again within hours without a decline in water surface levels. The difficulty in breaching the sandbar resulted in a longer than typical period of closure and elevated water surface levels in the Estuary. The 25 October and 25 November closures resulted in estuary water surface levels exceeding 8 ft because water surface levels increased more quickly than the typical 0.5 ft/day (up to 1.5 ft/day on some days), making it difficult to get crews onsite quickly.

Goals and Objectives of Monitoring Plan

Breaching the Estuary sandbar requires permits from state and federal regulatory agencies, including the U.S. Army Corps of Engineers (Corps). The Corps initiated consultation with the National Marine Fisheries Service (NMFS) under the federal Endangered Species Act to determine if issuing a permit for the Agency's breaching activities would be likely to affect listed salmonids. NMFS issued a Biological Opinion that the proposed estuary breaching is not likely to jeopardize the continued existence of listed salmonids and requiring the Agency to develop an estuary monitoring plan (National Marine Fisheries Service, Southwest Region 2005).

In accordance with the Biological Opinion, the goals of the monitoring plan (Martini-Lamb et al. 2005) are to:

- document the distribution, abundance, and condition of listed salmonids in the Russian River estuary;
- document salmonid residence times in the Estuary;
- and to assess the habitat parameters that affect salmonid presence and distribution in the Estuary.

The Agency, U.S. Army Corps of Engineers, and the Mendocino County Russian River Flood Control and Water Conservation Improvement District are consulting with the National Marine Fisheries Service under Section 7 of the Endangered Species Act. The consultation evaluates the effects of various operations and maintenance activities, including the Russian River Estuary Management Plan, on listed steelhead, Coho salmon, and Chinook salmon. A proposal under consideration in the consultation is the future reduction of summer minimum instream flows and managing the Russian River estuary as a summer lagoon to benefit salmon rearing in the Estuary. While this proposal is being evaluated through the Section 7 consultation process, the Agency continues to implement the Estuary Management Plan identified in the *Russian River Estuary Study 1992-1993*.

Monitoring salmonid occurrences and habitat parameters in the Estuary provides information regarding the presence of non-salmonid species and changes in water quality conditions related to changes in sandbar closure. This information may be used to further assess potential affects of current and future management on wildlife, fisheries, and habitat characteristics of the Estuary.

Monitoring

The Agency's Russian River Estuary Sandbar Breaching Monitoring Plan identified the water quality and fisheries monitoring to be performed in the Estuary (Martini-Lamb et al. 2005).

Water Quality

Water quality was monitored in the lower estuary between Bridgehaven and the mouth of the river (Figure 1). The data collected in 2005 represents the second year of water quality monitoring in the lower reach of the Estuary. The first year of monitoring (2004) was performed prior to the Agency receiving breaching permits requiring water quality monitoring. Data was collected to establish baseline information and gain a better understanding of the longitudinal and vertical water quality profile during the ebb and flow of the tide, as well as to track changes that may occur during periods of sandbar closure and reopening. Water quality monitoring data was collected at three stations during two complete estuary closure and breaching events, and at one station during part of a third closure event. Data was not collected during the fourth and final estuary closure and breaching event of the season.

Fisheries

Fisheries seining locations were distributed throughout the Estuary (Figure 1). A purse seine was used to determine the relative abundance and distribution of salmonids and other near-shore fishes in the Estuary. Seining events captured the first and second sandbar closures in

2005. Prior to receiving breaching permits requiring fisheries monitoring, the Agency collected baseline data using purse seines in 2003 and 2004. Results of those surveys are included in this report.

The Agency surveyed macro-invertebrates in the Estuary in 2004 and 2005. Although breaching permits do not require this monitoring, the survey results are presented in this report.

Juvenile Steelhead Residency Pilot Study

The first year of a two-year pilot study was implemented to evaluate the effectiveness of using acoustic telemetry and passive integrated transponder (PIT) tags to monitor juvenile steelhead summer residency in the Estuary. The purpose of the study is to determine the distribution and residence times of juvenile steelhead within the Estuary and to gain an understanding of how sandbar and water quality conditions may influence their presence and behavior (Fuller and Manning 2005). Fixed station and mobile tracking telemetry data was collected during the first three sandbar closures. Minimal mobile tracking data was collected during the final closure in 2005.

Methods

Water Quality

Water quality monitoring was conducted in the lower and middle reach of the Russian River estuary between Bridgehaven and the mouth of the river. Three stations were established for water quality monitoring: the mouth of the Russian River at Goat Rock State Beach (Mouth station); Penny Island near the Jenner boat ramp (Penny Island station); and just downstream from the Highway 1 bridge at Bridgehaven (Bridgehaven station). Monitoring was conducted between 13 June and 17 October 2005 at the Penny Island and Mouth stations, and between 14 June and 21 November 2005 at the Bridgehaven station. Monitoring stations were composed of a concrete anchor attached to a steel cable suspended from the surface by a large buoy. An array of multi-parameter, continuous monitoring equipment, referred to as datasondes (sondes), were deployed at each station to collect a vertical water quality profile. Stations were placed in deep holes along the lower estuary. The rationale for choosing these sites was to locate the deepest holes in the lower estuary in order to obtain the fullest vertical profiles possible and to monitor anoxic events and temperature or salinity stratification.

Three sondes were deployed at the Mouth: one near the bottom; one at mid-depth; and one near the surface at approximately 1 m in depth. Two sondes were deployed at Penny Island: one at the bottom and one at mid-depth. Three sondes were deployed at Bridgehaven: one at the bottom; one at mid-depth; and one near the surface at approximately 1 m in depth.

Water quality was monitored using YSI 6600 multi-parameter sondes. Hourly salinity (parts per thousand), water temperature (degrees Celsius), dissolved oxygen (milligrams per liter), and pH (hydrogen ion) data were collected. Sondes were cleaned and recalibrated every three weeks and data was downloaded during each calibration event.

Fisheries

The Estuary fisheries monitoring area consisted of the tidally-influenced section of the Russian River from the sandbar at the Pacific Ocean to the confluence with Austin Creek, located 11.7 km (7.3 mi) upstream from the coast (Figure 1).

Fish Surveys

A beach-deployed purse seine was used to sample fish species, including salmonids, and determine their relative abundances and distributions within the Estuary. The seine was 30 m long (100 ft long) and 3 m deep (10 ft deep) with pull ropes attached to both ends. Floats on the top and metal rings on the bottom of the net position the seine vertically in the water. The purse seine was deployed with a boat to pull an end offshore and then around in a half-circle while the other end was held onshore. Once the ends of the seine were brought together at the shore, the purse line was pulled to close, or “purse,” the net to prevent fish from escaping. The net was then hauled onshore by hand. Fish were placed in an aerated bucket for sorting, identification, and counting prior to release. Salmonids were anesthetized with Alka-seltzer tablets and then measured, weighed, and examined for general condition, including life stage (i.e., parr, smolt). Fish were allowed to recover in aerated buckets prior to release.

Eight seining stations were located throughout the Estuary in a variety of habitat types based on substrate type (i.e., mud, sand, and gravel), depth, and tidal and creek tributary influences (Figure 1). The habitat characteristics and locations of the seining stations were:

- River Mouth: on the sand bar separating the Russian River from the Pacific Ocean, sandy substrate with a steep slope, high tidal influence
- Penny Island: in shallow water with a mud and gravel substrate, high tidal influence
- Jenner Gulch: at the confluence with a small creek, gravel substrate with a moderately-steep slope, influenced by tides and creek flows
- Patty Rock: on a large gravel bar adjacent to deep water, moderate tidal influences
- Willow Creek: in shallow waters at the confluence with a creek, gravel and mud substrate, influenced by creek flows and moderate tidal action
- Sheephouse Creek: at the confluence with a creek, gravel substrate with a moderately-steep slope, influenced by creek flows and moderate tidal action
- Heron Rookery: on a gravel bank adjacent to deep water, moderate tidal influences
- Austin Creek: at the confluence with a perennial creek, gravel substrate with a moderately-steep slope, freshwater influence from the creek

Three seine pulls were deployed at each station. Stations were surveyed approximately every 3 weeks and during different tidal cycles from 24 May to 26 August 2004 and 31 May to 6 October 2005.

Macro-invertebrate Surveys

The purpose of the surveys is to determine the relative abundance and distribution of macro-invertebrates in the Estuary. Surveys in the lower and middle estuary focused on marine species. Six permanent trap stations were distributed between the Russian River mouth and 6.4 km (4.0 mi) upstream in a variety of habitat types based on substrate type (e.g., mud, sand, gravel, rock; Figure 1). Traps were set approximately every 2 to 3 weeks from 18 May to 1 September 2004, and from 15 June to 14 September 2005. One shrimp trap and one crab trap baited with fish parts composed each station. Traps were deployed during the morning and retrieved the following morning. Captured invertebrates were identified to species, carapace width measured, and released. Dungeness crabs (*Cancer magister*) with carapace widths of <100 mm were considered juvenile and adults were $\geq$100 mm.

Juvenile Steelhead Residency Pilot Study

Fish Capture, Acoustic Tagging, and Tracking

To investigate juvenile steelhead behavior in the Russian River estuary, we captured, acoustically tagged, and released fish at multiple sites. Steelhead with surgically implanted acoustic transmitters were then tracked for 4 months (30 July to 11 November 2006) from the river’s mouth upstream to Austin Creek (approximately river kilometer (rkm) 11.7, Figure 1).

A 30-m-long beach seine was the primary method of fish capture. An electrofishing boat was used twice to increase capture efforts. The size and weight of the transmitters (Lotek MAP8-5S, 8.5 mm diameter, 32 mm long, 4 g in air, 2.5 g in water) limited the size of fish that could be tagged. All surgical tag implantations were performed in the field and used juvenile steelhead with a tag weight to fish weight ratio of <10% to avoid adverse effects on swimming and natural behavior. Fish were immediately released at the site of capture after recovering from anesthesia. The transmitters emitted a uniquely coded signal every 5 seconds (s) at 200 kHz and had an estimated battery life of 120 days.

To monitor tagged fish passage, three fixed hydrophone-receiving stations were placed in the upper, middle, and lower reaches of the Estuary. The stations were located near Duncans Mills bridge (rkm 10.2), Sheephouse Creek (rkm 5.37), and downstream of Penny Island (rkm 0.51; Figure 1). Each station was composed of two submerged hydrophones and a 12-volt, battery-powered datalogging receiver (Lotek® MAP 600 RT). The submerged hydrophones were staggered up and down stream in an attempt to determine the direction fish were moving.

Once deployed, each fixed station was periodically tested for detection probability and range by suspending a transmitter at various depths below a surface float. By releasing the floats at incremental distances from the hydrophones, we determined the detection probability of passing tagged fish and maximum detection range. The fixed hydrophone-receiver stations were all deployed in areas where full detection was gained across the active river channel. Data was downloaded weekly using Lotek software (Biomap) and a laptop computer for the duration of the study.

To generate more detailed information about fish movement, we supplemented data from the fixed stations with manual tracking. Transmitter signals were detected from a motorized boat equipped with 2 hydrophones connected to a receiver and laptop computer. Weekly tracking surveys were conducted from the river mouth to Brown's Riffle (20 m downstream of the Austin Creek confluence) during ebb and flood tide (Figure 1). During a sandbar closure event or an extreme high tide, the manual tracking survey was extended past Brown's Riffle to the mouth of Austin Creek. We also conducted one-time manual tracking surveys in Austin Creek, 1.6 km above the mouth, and in the main stem river approximately 3 km above the Austin Creek confluence.

Fish locations were documented by recording latitude and longitude using a hand-held GPS receiver and marking a laminated aerial photograph when maximum signal strength was gained. When fish were located, salinity, D.O., and temperature were collected from the surface to the bottom every 0.5 m to create a vertical water quality profile. Lunar phase (i.e., new moon, first quarter, last quarter, or full moon) and tidal direction (i.e., flood, slack high, ebb, or slack-low) were also noted. The last manual tracking survey was conducted 4 days following the removal of the fixed stations.

Determination of Residence Time, Growth Rate, and Habitat Use at Austin Creek

To gain information on residence time, growth rate, and habitat use of juvenile steelhead at the Austin Creek site, we tagged 100 fish with passive integrated transponder (PIT) tags from mid-June to early August. The PIT tags were 12-mm-long by 2.1-mm-diameter glass-encapsulated electronic devices that carried a unique code. The PIT tags were inserted into the body cavity with a hypodermic needle. All fish were collected by beach seining and held in mesh pens placed in the cooler water of Austin Creek to reduce handling stress. Upon initial and subsequent recaptures, fish were anesthetized, weighed, measured, allowed to recover, and immediately released at the capture site.

Results

Water Quality

Water quality conditions were similar to those recorded in 2004. The lower and middle reaches of the Estuary are predominantly saline environments with a thin freshwater layer that flows over the denser saltwater. Mean and maximum water temperatures at all 3 stations were typically lower at the bottom and mid-depth sondes, which were located primarily in saltwater and higher at the surface sondes, which were located primarily in freshwater. Mean D.O. levels were highest at the surface sondes, although all sondes experienced significant fluctuations in D.O. concentrations throughout the season. Hydrogen ion (pH) levels tended to be basic (>7 pH) and fairly consistent among all sondes, with the surface sondes having slightly higher values. The following sections provide a brief discussion of the results observed for each parameter listed above. There are several data gaps among the various sondes due to malfunction and maintenance issues. Data associated with malfunctioning equipment has been removed from the data sets, resulting in the data gaps observed in the graphs presented as Figures 2 through 13.

Salinity

As stated above, all of the bottom and mid-depth sondes were located primarily in saltwater whereas the two surface sondes were located at the saltwater-freshwater interface (salt wedge). Full strength seawater has a salinity of approximately 35 ppt, with salinity decreasing from the ocean to the upstream limit of the estuary, which is considered freshwater at approximately 0.5 ppt (Horne 1994).

The surface sondes at Bridgehaven and the Mouth were suspended at approximately 1 m in depth, and experienced frequent hourly fluctuations in salinity concentrations. This fluctuation is caused by movement of the salt wedge. A salt wedge occurs where saltwater and freshwater meet, whereby the denser saltwater sinks below the lighter freshwater. This salt wedge moves up and down the estuary with the tides and is affected in part by freshwater inflows, the bottom topography, and wind. Salinity levels at the Bridgehaven and Mouth surface sondes had mean values of 13.6 and 18.5 ppt, respectively (Table 2). However, concentrations ranged from 0.2 to 33.6 ppt at the Bridgehaven surface sonde and from 1.5 to 32.4 ppt at the Mouth surface sonde.

Salinity levels at the bottom and mid-depth sondes had mean values between 30.1 and 31.7 ppt and ranged from 19.3 to 33.8 ppt with the exception of the Bridgehaven mid-depth sonde, which experienced a low concentration of 2.3 ppt during an estuary breaching event (Table 2). The Bridgehaven mid-depth sonde experienced rapid drops in salinity concentrations immediately following breaching of the sandbar on 17 October and 1 November 2005. Both events occurred within hours of the Estuary breaching and lasted approximately 18 hours each; however, the 17 October event experienced a significantly larger change in salinity than the 1 November event (Figure 2). Salinity levels on 17 October decreased from approximately 30 ppt to 2 ppt, compared to a decrease from approximately

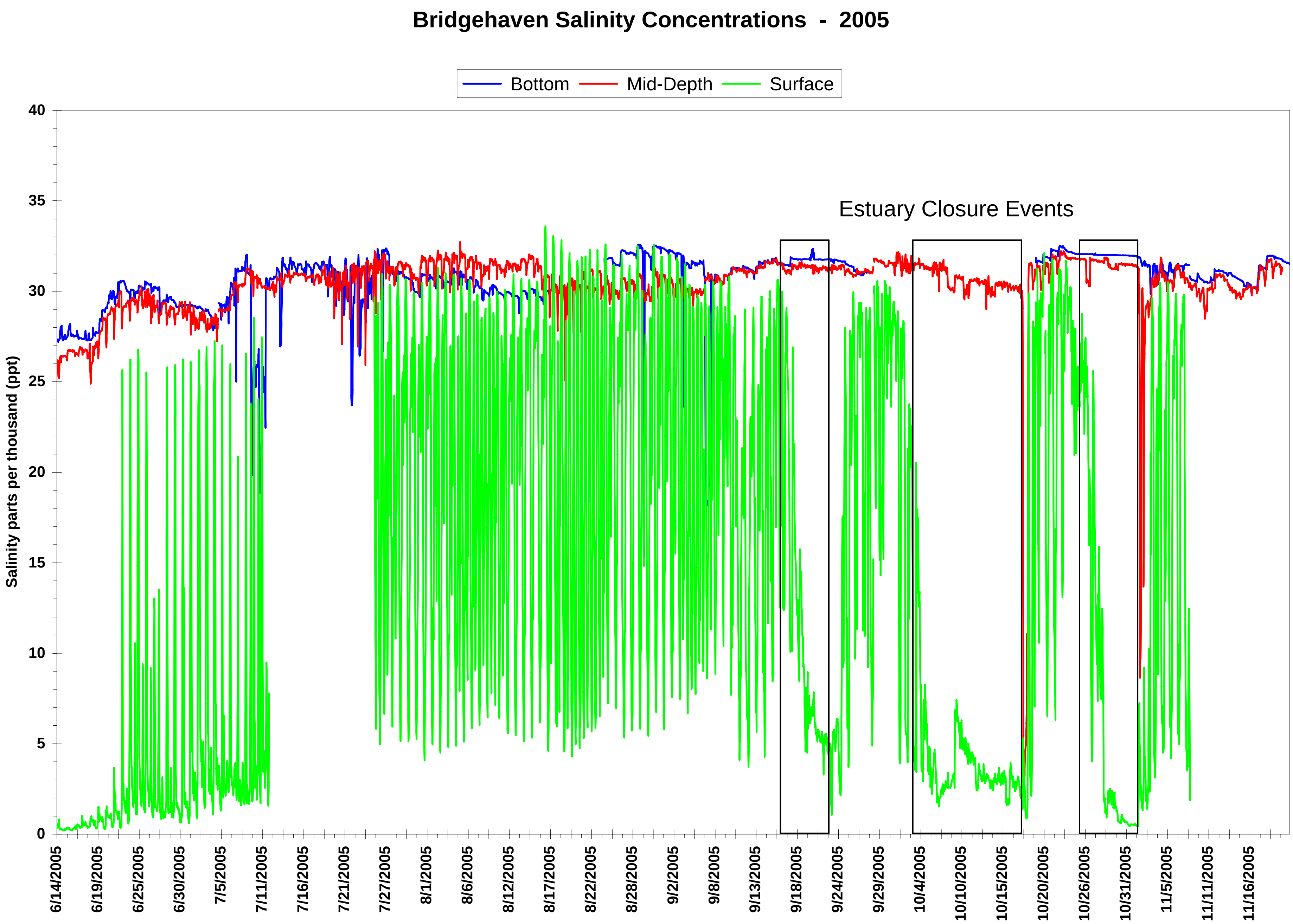


Figure 2. Bridgehaven monitoring station salinity concentrations during the 2005 Russian River estuary water quality monitoring.

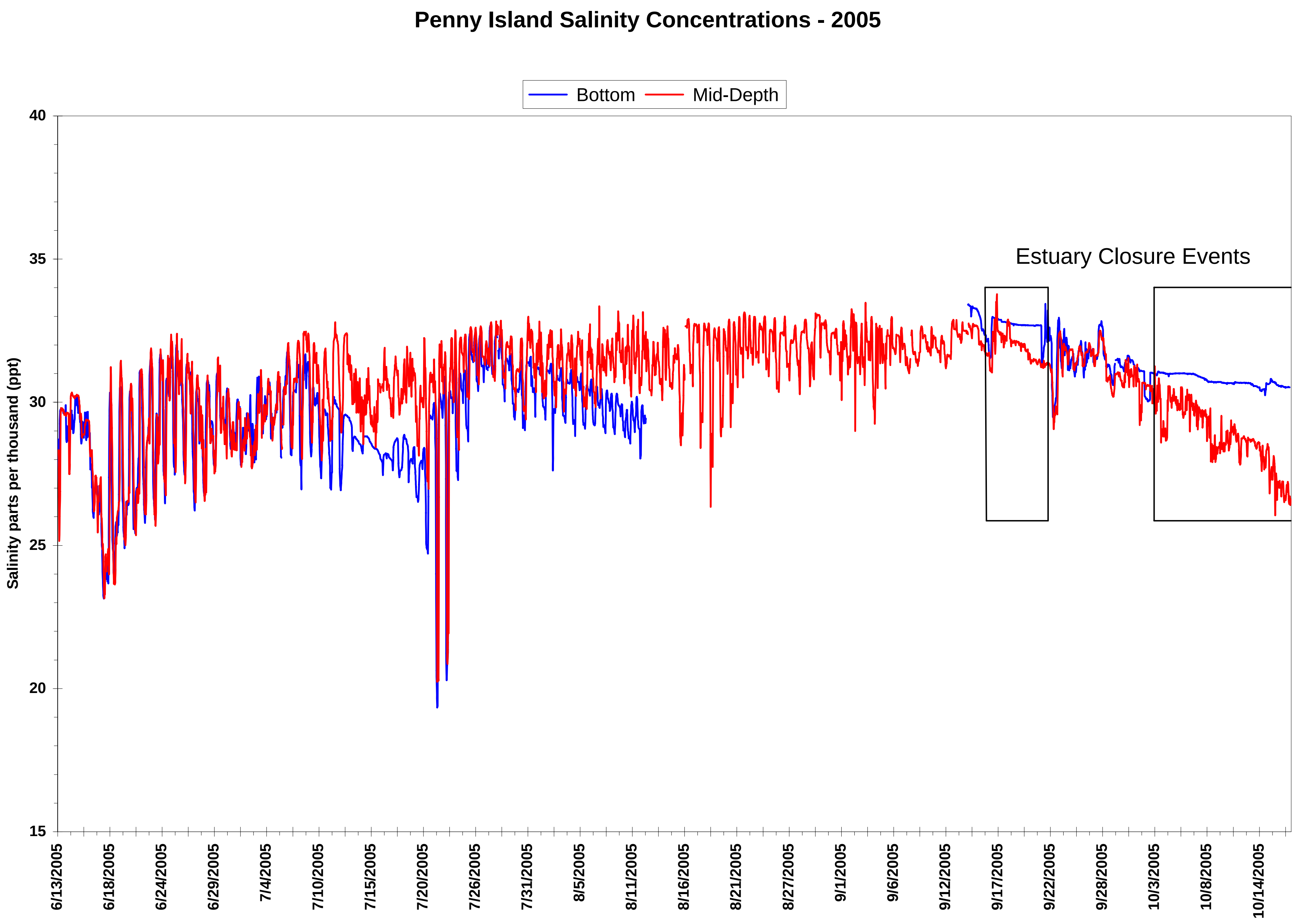


Figure 3. Penny Island monitoring station salinity concentrations during the 2005 Russian River estuary water quality monitoring.

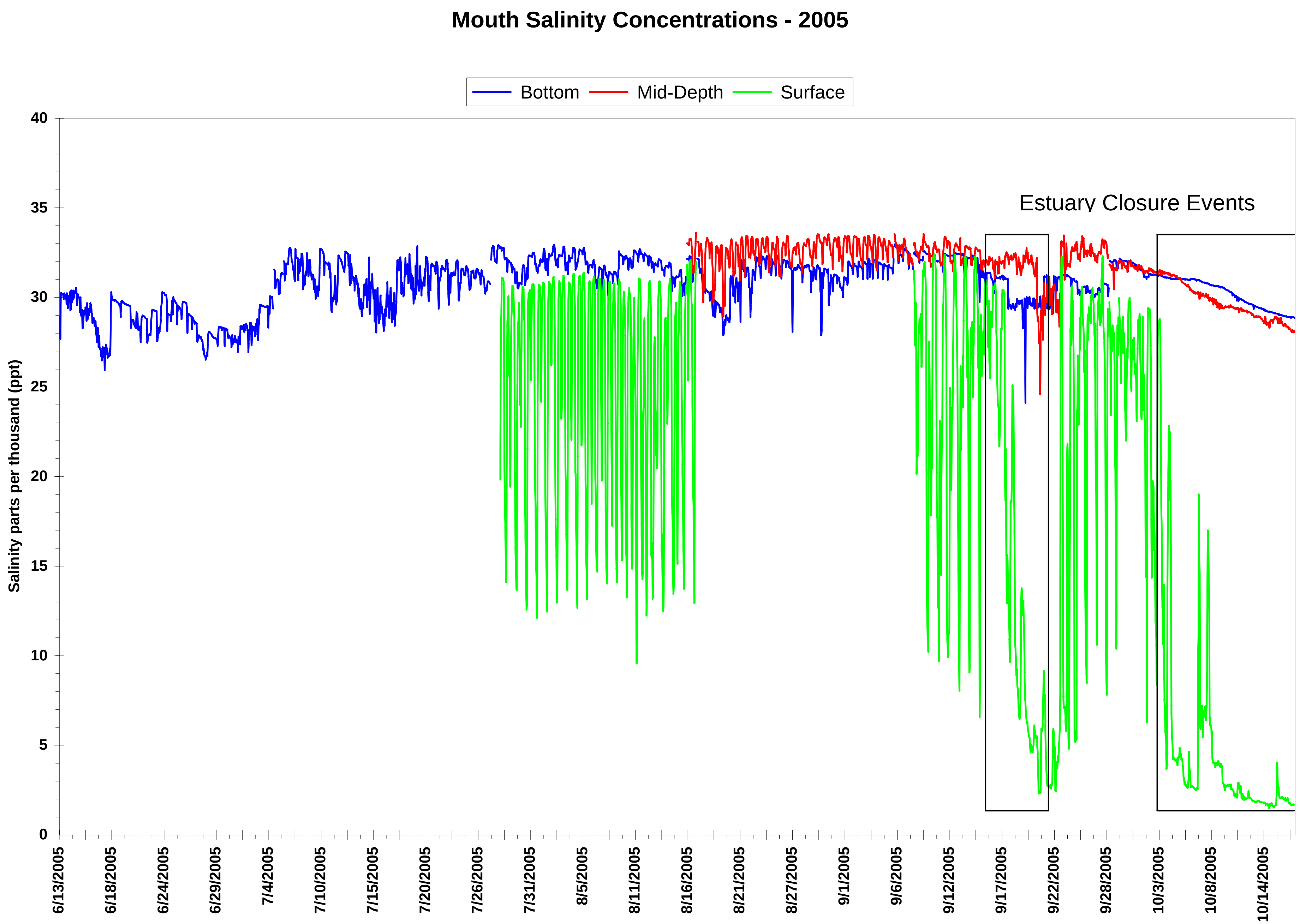


Figure 4. Mouth of the Russian River monitoring station salinity concentrations during the 2005 Russian River estuary water quality monitoring.

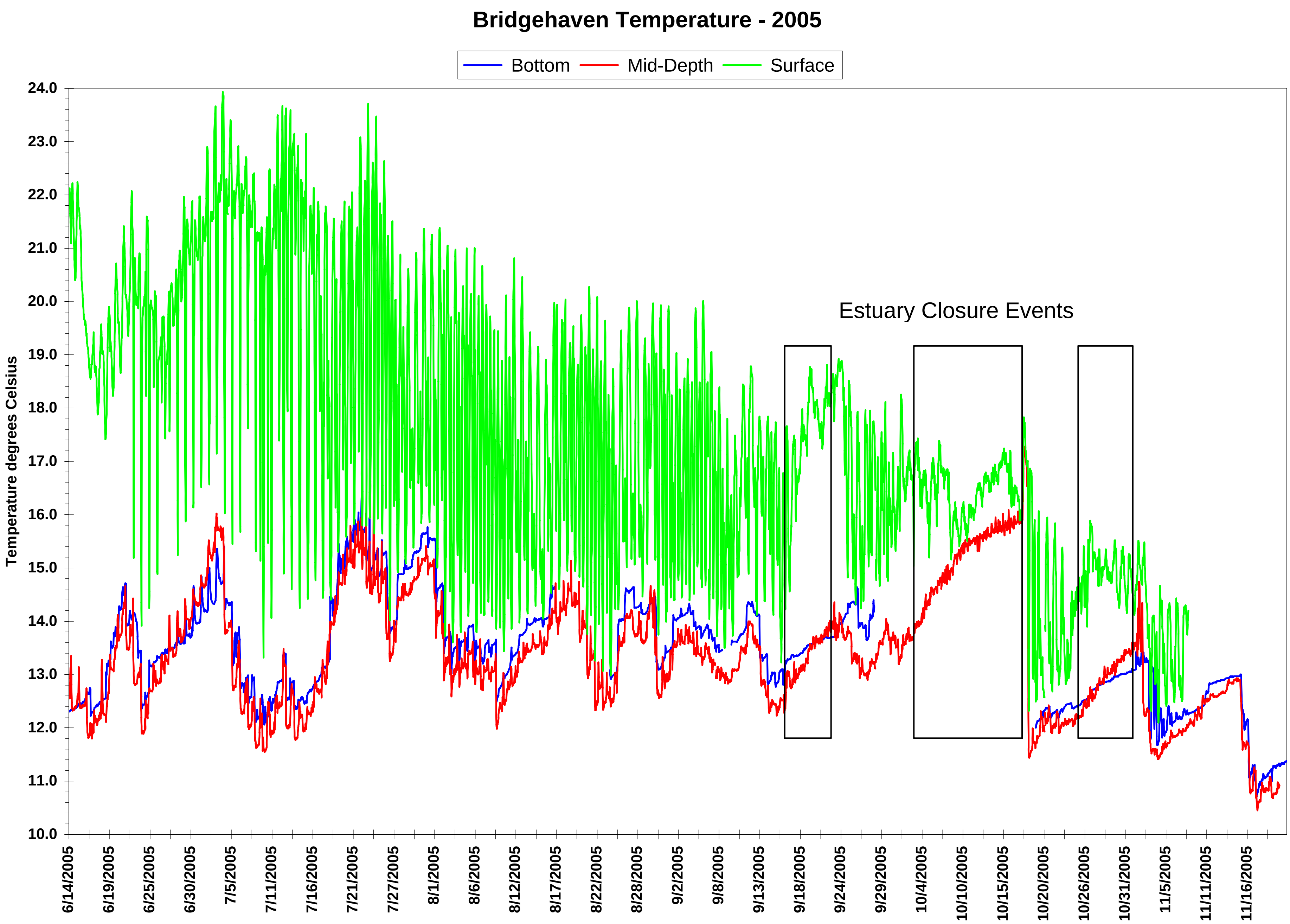


Figure 5. Bridgehaven monitoring station temperatures during the 2005 Russian River estuary water quality monitoring.

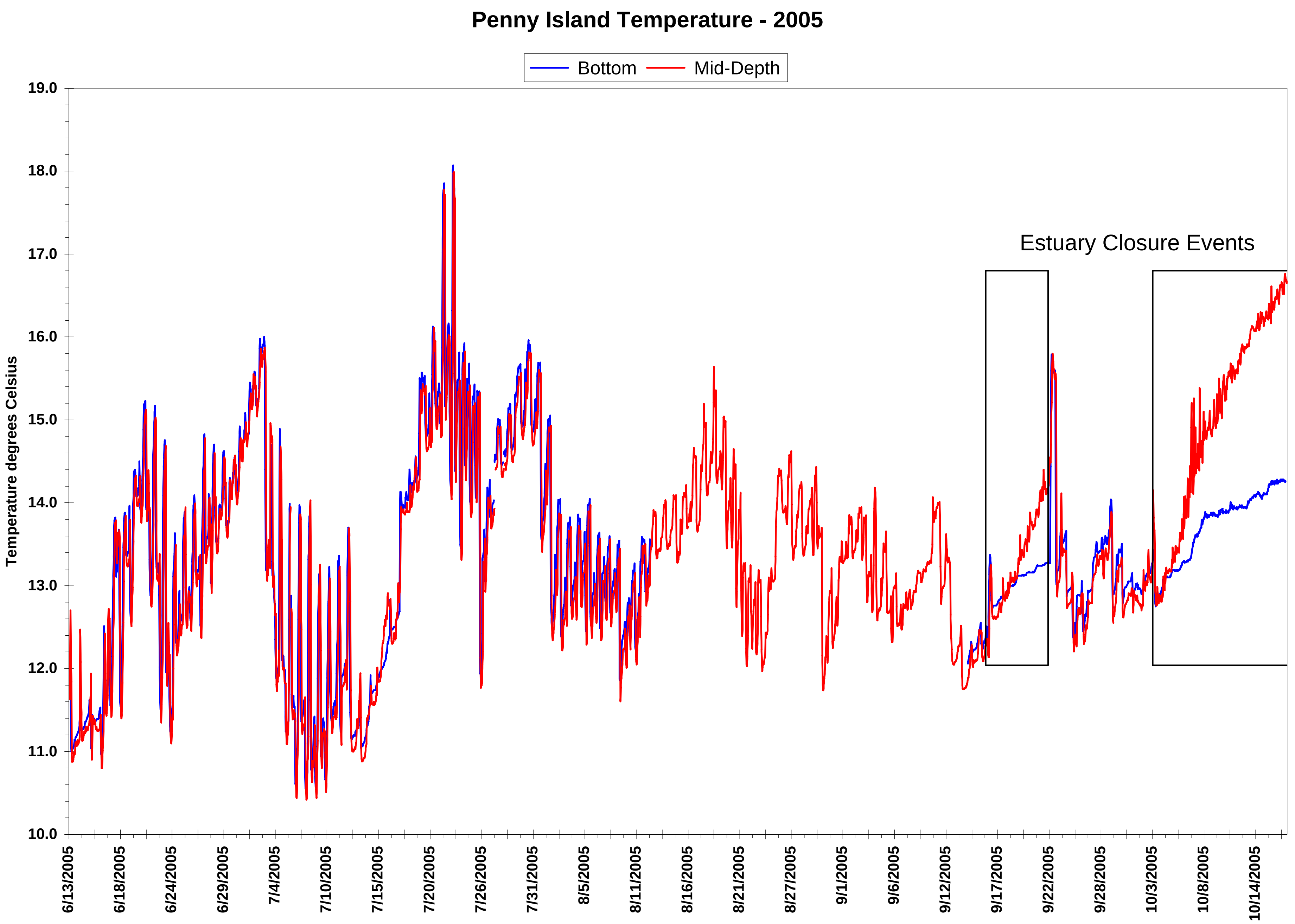


Figure 6. Penny Island monitoring station temperatures during the 2005 Russian River estuary water quality monitoring.

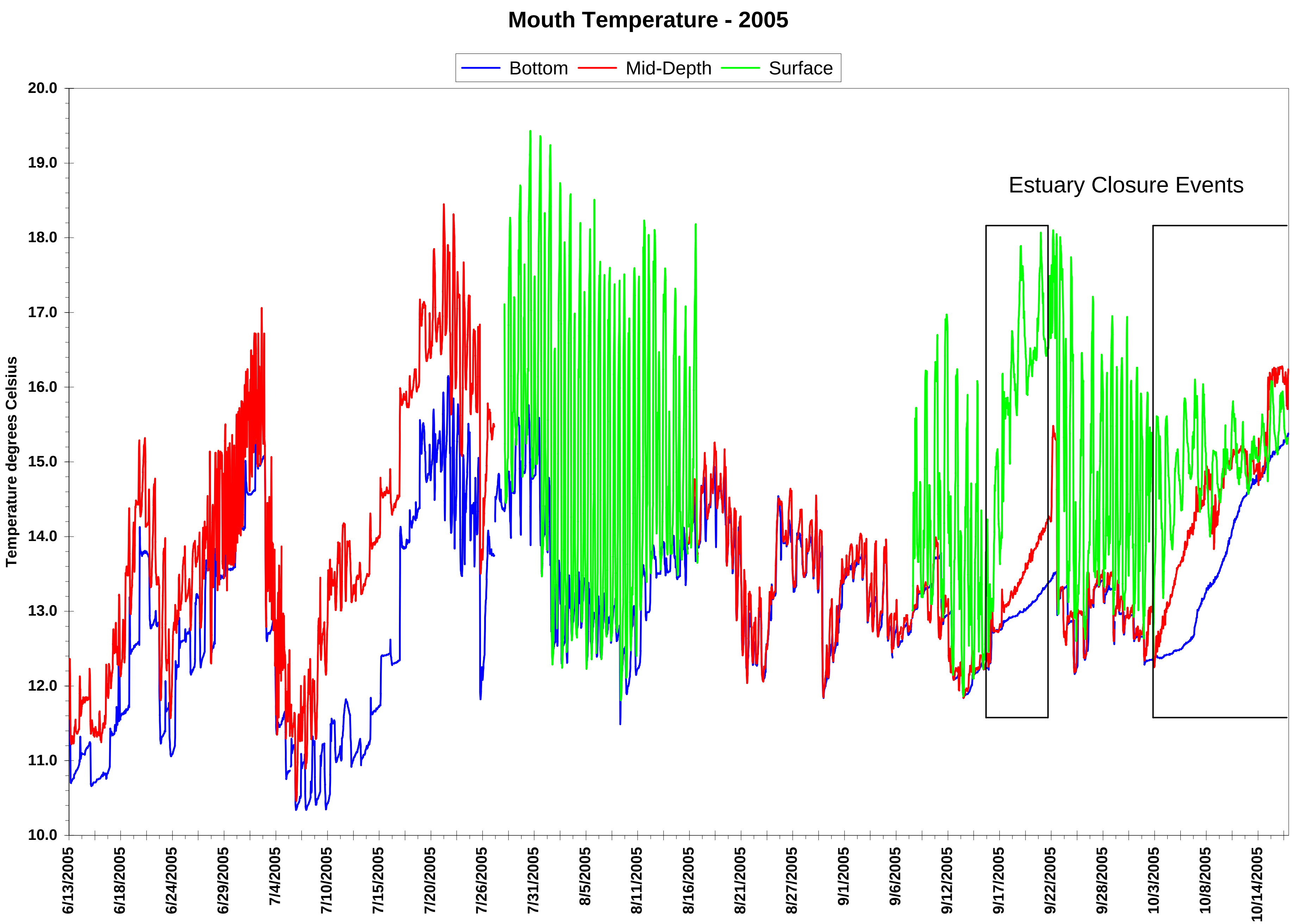


Figure 7. Mouth of the Russian River monitoring station temperatures during the 2005 Russian River estuary water quality monitoring.

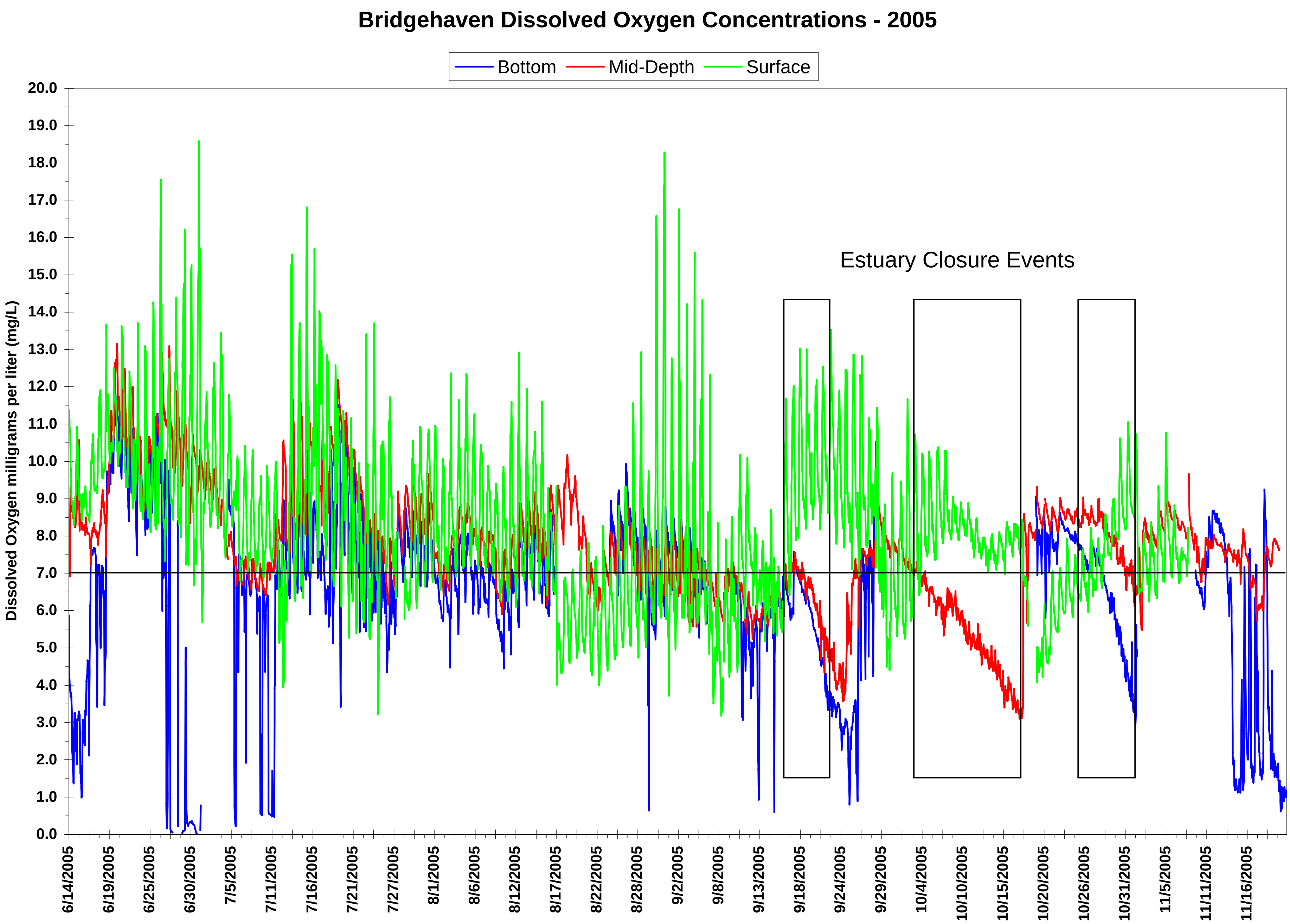


Figure 8. Bridgehaven monitoring station dissolved oxygen concentrations during the 2005 Russian River estuary water quality monitoring.

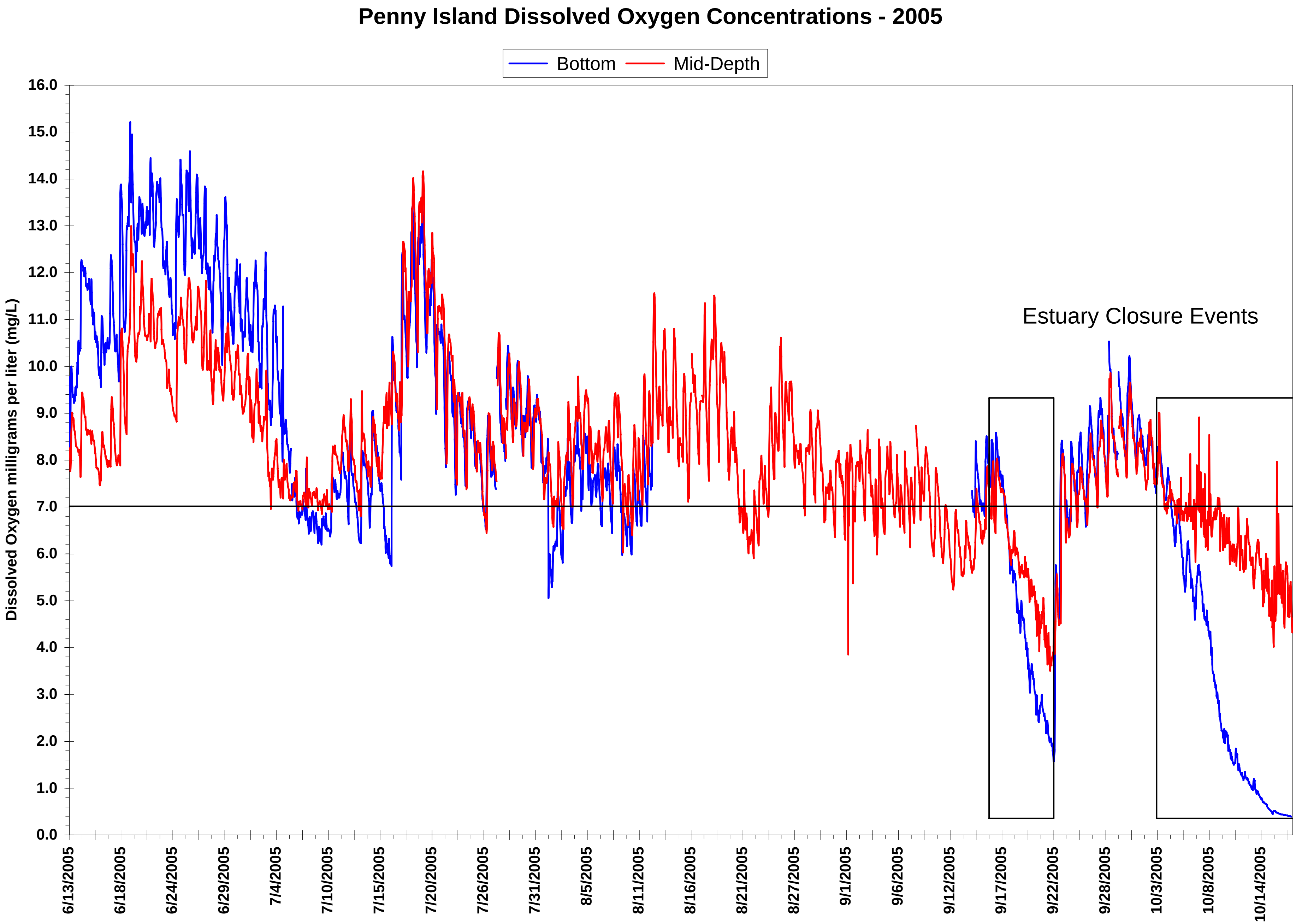


Figure 9. Penny Island monitoring station dissolved oxygen concentrations during the 2005 Russian River estuary water quality monitoring.

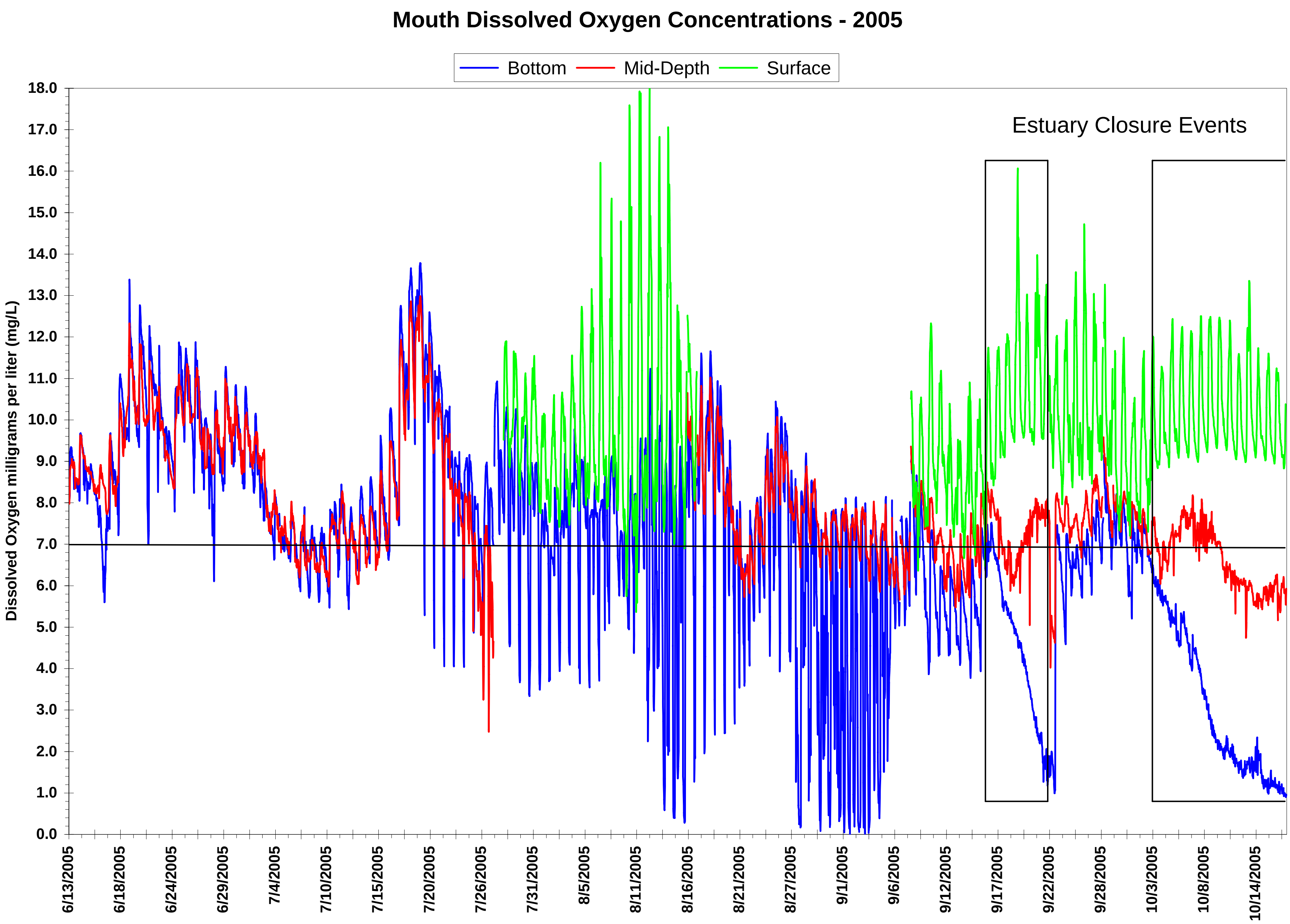


Figure 10. Mouth of the Russian River monitoring station dissolved oxygen concentrations during the 2005 Russian River estuary water quality monitoring.

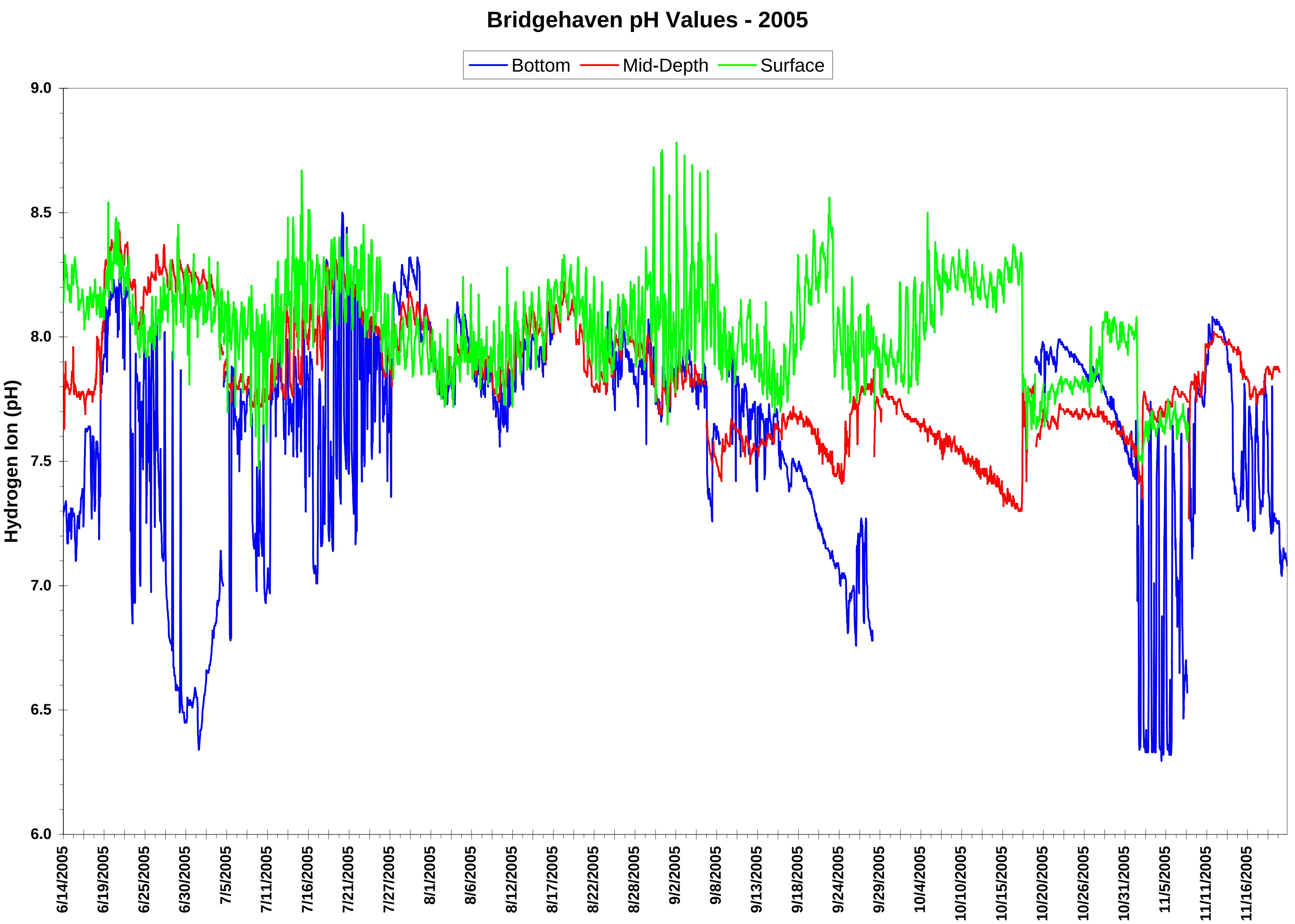


Figure 11. Bridgehaven monitoring station pH values during the 2005 Russian River estuary water quality monitoring.

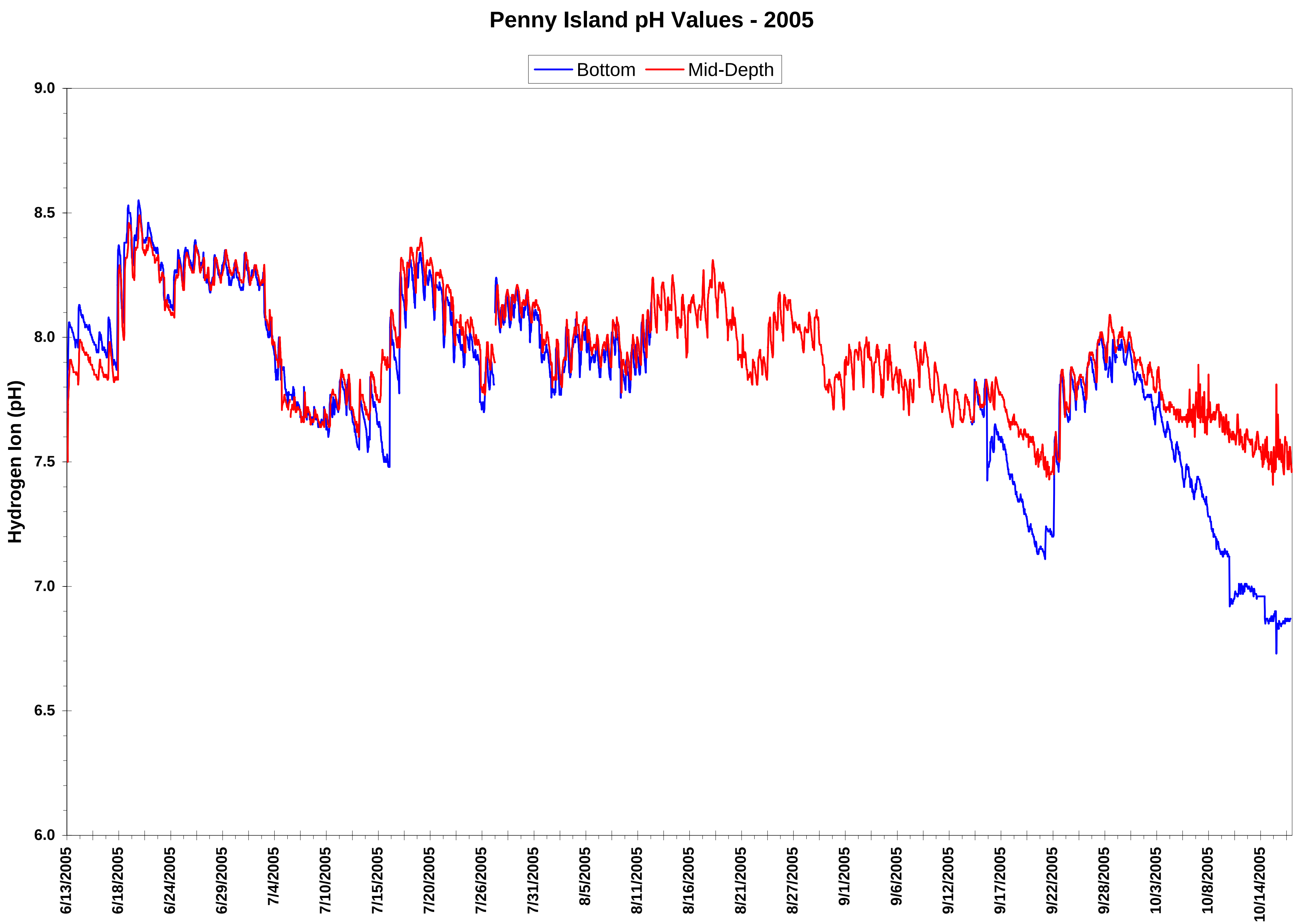


Figure 12. Penny Island monitoring station pH values during the 2005 Russian River estuary water quality monitoring.

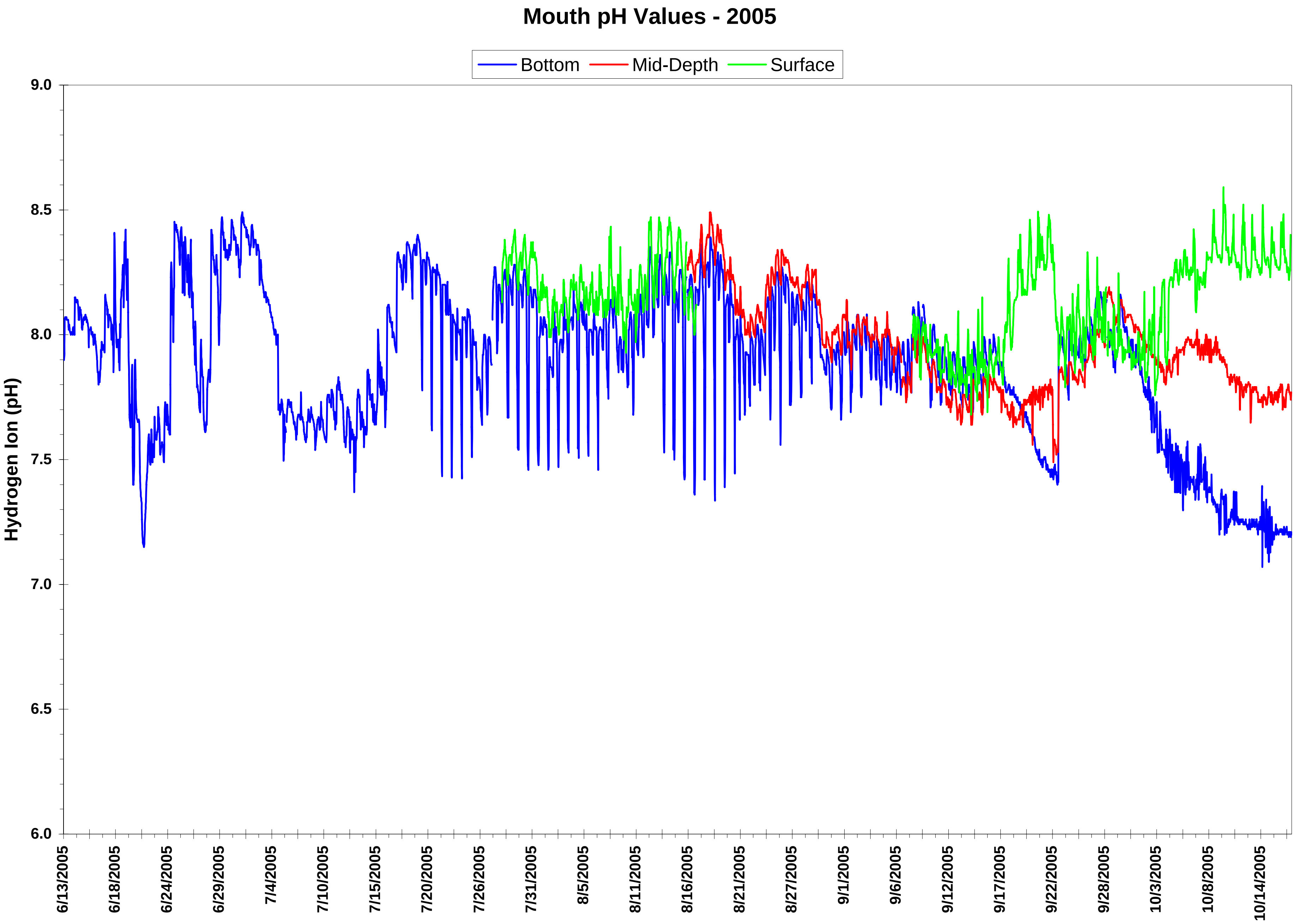


Figure 13. Mouth of the Russian River monitoring station pH values during the 2005 Russian River estuary water quality monitoring.

Table 2. Russian River estuary breaching 2005 monitoring water quality results. Minimum, maximum, and mean depth (m), water temperature (degrees C), specific conductance (mS/cm), dissolved oxygen (mg/L), hydrogen ion (pH), and salinity (ppt). Data was collected from 13 June to 21 November 2005 at the Bridgehaven monitoring station. Data was collected from 13 June to 17 October 2005 at the Penny Island and mouth of the Russian River monitoring stations. The Penny Island station did not include a surface sonde.

Monitoring Station *Sonde*	**Depth (m)**	**Temp (degrees C)**	**SpCond (mS/cm)**	**D.O. (mg/L)**	**pH**	**Salinity (ppt)**
Bridgehaven						
Surface						
Min	0.6	12.1	0.4	3.2	7.5	0.2
Max	2.2	23.9	51.2	18.6	8.8	33.6
Mean	1.1	17.4	21.8	8.2	8.0	13.6
Mid-depth						
Min	3.3	10.5	4.4	3.1	7.3	2.3[a]
Max	4.9	17.3	50.0	13.3	8.4	32.7
Mean	4.3	13.4	46.8	7.7	7.8	30.4
Bottom						
Min	4.9	10.7	25.6	0.0	6.3	6.6
Max	9.0	16.3	49.8	11.8	8.5	32.6
Mean	7.9	13.4	47.1	6.5	7.6	30.5
Penny Island						
Mid-depth						
Min	3.8	10.4	32.4	3.5	7.4	20.3
Max	4.9	18.0	51.5	14.2	8.5	33.8
Mean	4.7	13.5	47.1	8.1	7.9	30.6
Bottom						
Min	4.7	10.6	31.0	0.4	6.7	19.3
Max	8.1	18.1	51.0	15.2	8.6	33.4
Mean	6.3	13.3	46.4	8.0	7.8	30.1
Mouth of the Russian River						
Surface						
Min	0.7	11.8	2.9	5.4	7.7	1.5
Max	1.4	19.4	49.6	18.3	8.6	32.4
Mean	1.2	15.0	29.2	9.9	8.1	18.5
Mid-depth						
Min	3.4	10.5	38.6	2.5	7.5	24.6
Max	4.9	18.4	51.2	13.0	8.5	33.6
Mean	4.6	13.7	48.6	7.9	7.9	31.7
Bottom						
Min	6.4	10.3	38.0	0.0	7.1	24.1
Max	9.8	16.2	50.4	13.8	8.7	33.0
Mean	8.0	13.1	47.3	6.9	7.9	30.7

30 ppt to 9 ppt on 1 November. Additionally, whereas the event on 17 October was observed to be a constant decrease in concentration before recovery, the 1 November event had several spikes in concentration before fully recovering.

Temperature

Water temperatures were reflective of the salt wedge with the bottom sondes having the lowest mean and maximum temperatures and the surface sondes having the highest mean and maximum temperatures.

The bottom and mid-depth sondes were located primarily in saltwater and had maximum temperatures that ranged between 16.2 and 18.4 degrees C, whereas the surface sondes had maximum temperatures of 23.9 and 19.4 degrees C at Bridgehaven and the Mouth, respectively (Table 2).

The differences in maximum temperatures between the surface sondes and the mid-depth and bottom sondes can be attributed in part to the source of each water type. The Pacific Ocean, where temperatures are typically around 10 degrees C, is the source of saltwater in the estuary. The Russian River, with temperatures reaching as high as 25 degrees C in the interior valleys, is the primary source of freshwater in the estuary.

The Bridgehaven surface sonde also had a much higher maximum temperature of 23.9 degrees C when compared to the maximum of 19.4 degrees C recorded at the Mouth surface sonde (Table 2). The overall higher temperatures observed at the Bridgehaven surface sonde were partially the result of a different monitoring period than at the Mouth, where data was not collected until after the highest seasonal temperatures at the Bridgehaven surface sonde had occurred.

The difference can also be attributed to the location of Bridgehaven, which is approximately 3.6 km (2.25 mi) upstream from the Mouth station and behind a ridgeline to the west and south that provides partial protection from marine fog and wind. Because the Bridgehaven station is the furthest upstream, the freshwater layer has the least amount of cooling time as the river leaves the warmer canyons around Guerneville and Monte Rio.

Mean temperatures at the bottom and mid-depth sondes were observed between 13.1 and 13.7 degrees C, whereas the surface sondes mean temperatures were 17.4 degrees C at Bridgehaven and 15.0 degrees C at the Mouth (Table 2).

The bottom sondes at Bridgehaven and the Mouth experienced very similar temperature regimes and ranged from 10.3 to 16.3 degrees C (Table 2). The Bridgehaven bottom sonde had a mean temperature of 13.4 degrees C, while the Mouth bottom sonde had a mean temperature of 13.1 degrees C (Table 2).

The Penny Island bottom sonde is located in a shallower hole than the Bridgehaven or the Mouth bottom sondes. The mean depth of the Penny Island bottom sonde was 6.3 m, compared with 8.0 m at Bridgehaven and 7.9 m at the Mouth (Table 2). During low tides, the Penny Island bottom sonde was between 4 and 5 m in depth, which is closer to the mean depth of the mid-depth sondes than the mean depth of the other two bottom sondes.

This may explain why temperature values observed at the Penny Island bottom sonde appear to track the values of the mid-depth sondes more closely than the other bottom sondes. While the bottom and the mid-depth sondes had similar mean values (approximately 13 degrees C), the maximum temperatures observed at the mid-depth sondes and Penny Island bottom were 1 to 2 degrees C higher than the other bottom sondes.

Dissolved Oxygen

Dissolved oxygen concentrations in the lower estuary were generally observed to be higher at the surface sondes, followed by the mid-depth sondes and then the bottom sondes. The surface sondes typically had the highest mean D.O. concentrations, as well as the highest maximum and minimum concentrations, when compared with the mid-depth and bottom sondes at a given sampling station.

The Bridgehaven and Mouth surface sondes had mean D.O. concentrations of 8.2 mg/L and 9.9 mg/L, respectively (Table 2). All three mid-depth stations were fairly consistent and had mean concentrations between 7.7 and 8.1 mg/L (Table 2). The bottom sondes at Bridgehaven and the Mouth had mean D.O. concentrations of 6.4 and 6.8 mg/L, whereas the Penny Island bottom sonde had a mean concentration of 8.0 mg/L (Table 2).

With a mean D.O. concentration of 8.0 mg/L, the Penny Island bottom sonde appeared to have conditions that were similar to the mid-depth sondes (Table 2). However, different monitoring periods caused by equipment malfunction contributed to some of the differences in values among bottom sondes. For example, the Penny Island bottom sonde was not operational for approximately 30 days in August and September, at a time when the Mouth and Bridgehaven bottom sondes were recording frequent, short-term anoxic events with D.O. concentrations below 1 mg/L (Figures 8 to 10). Yet, the Penny Island bottom sonde was operational in June and July and did not experience the anoxic events observed at the Bridgehaven bottom sonde in the same months.

Significant fluctuations in D.O. concentrations were observed in the lower estuary. Several short-term anoxic events were recorded at the bottom sondes throughout the season along with more pronounced anoxic events occurring during periods of estuary closure.

Short-term anoxic events did not appear to be related to a specific tidal cycle and typically lasted on the order of a few to several hours. In addition, this frequent hourly fluctuation was observed to last up to several days at a time. For example, several short-term events occurred at the Mouth bottom sonde over a period of approximately 11 days (Figure 10).

Prolonged anoxic events at the two deepest bottom sondes (Bridgehaven and Mouth), especially during estuary closure, likely contributed to the lower seasonal mean for those sondes. The data indicated a downward trend in D.O. concentrations, including periods of prolonged anoxia, for the duration of estuary closure. Dissolved oxygen concentrations would generally recover within hours of the sandbar breaching, with the exception of the Bridgehaven bottom sonde after the first breaching event.

Depressed D.O. conditions remained at the Bridgehaven station for approximately 4 days after the first breaching event reopened the river mouth (Figure 8). It is possible that several tidal cycles were necessary to push enough oxygenated saltwater to the furthest upstream station and either mix with or flush out the anoxic water. However, there may be other factors that contributed to this extended anoxia, as it was not observed to persist following subsequent breaching events.

Consequently, all sondes at all depths did experience some degree of fluctuating D.O. concentrations, especially during periods of estuary closure. However, D.O. concentrations at the surface sondes did not appear to be negatively impacted by estuary closure and were observed to either remain similar to pre-closure conditions or increase in some instances. Additional data collection and analysis would be needed to further explore whether any of these conditions represent trends.

Overall, the bottom sondes were observed to experience the most frequent, severe, and prolonged anoxic events when compared with the mid-depth and surface sondes. All three bottom sondes recorded prolonged anoxic events for the duration of the estuary closure events in September and October 2005. The Penny Island and Bridgehaven mid-depth sondes also recorded decreasing D.O. concentrations during estuary closure, with concentrations dropping as low as 3 to 4 mg/L before recovering after the sandbar was breached. The Mouth mid-depth sonde experienced reduced D.O. concentrations during estuary closure, but to a lesser degree than the other two mid-depth sondes.

Although the Bridgehaven and Mouth surface sondes had minimum seasonal D.O. concentrations of 3.2 and 5.4 mg/L, these values did not coincide with any of the estuary closures (Table 2).

The surface sondes, and mid-depth and bottom sondes to a lesser degree, also experienced hourly fluctuating super-saturation events. At times when oxygen production exceeds the diffusion of oxygen out of the system, supersaturation may occur (Horne 1994). D.O. concentrations exceeding 100% saturation in the water column are considered supersaturated conditions. Because the ability of water to hold oxygen changes with temperature, there are a range of concentration values that correspond to 100% saturation. For instance, at sea level, 100% saturation is equivalent to approximately 11 mg/L at 10 degrees C, but only 8.2 mg/L at 24 degrees C. Consequently, these two temperature values roughly represent the range of temperatures observed in the Estuary during the 2005 monitoring season.

Maximum D.O. concentrations at the Bridgehaven and Mouth surface sondes were observed to be approximately 18.6 (238%) and 18.3 mg/L (211%), respectively (Table 2).

Maximum D.O. concentrations at the mid-depth sondes were approximately 13.3 (152%) at Bridgehaven, 14.2 (170%) at Penny Island, and 13.0 mg/L (160%) at the Mouth.

Maximum D.O. concentrations at the Bridgehaven, Penny Island and the Mouth bottom sondes were approximately 11.8 (137%), 15.2 (174%), and 13.8 mg/L (167%), respectively. (Table 2).

Hydrogen Ion (pH)
Hydrogen ion (pH) values were fairly consistent among all stations at all depths, with mean values ranging from 7.6 pH at the Bridgehaven bottom sonde to 8.1 pH at the Mouth surface sonde. Minimum pH values were observed to remain above 7 pH throughout the monitoring season, with the exception of the Bridgehaven and Penny Island bottom sondes, which had minimum values of 6.3 and 6.7 pH, respectively (Table 2). Maximum pH values were also fairly consistent and ranged from 8.4 pH at the Bridgehaven mid-depth sonde to 8.8 pH at the Bridgehaven surface sonde.

Fisheries

Fish and macro-invertebrate studies include findings from monitoring in 2004 (Cook 2005) and 2005, and preliminary results from 2003 (Cook 2004).

Distribution and Abundance of Common Species
A total of 8,440 fish from 20 species were recorded in the Estuary during 2005 (Table 3). In comparison, fish surveys from 1992 to 1993 and from 1996 to 2000 found 18 to 28 species/year (Sonoma County Water Agency and Merritt Smith Consulting 2001). Forty-nine species were detected during the 7 years of monitoring. Twenty-two fish species were recorded in 2003 and thirty-one species were recorded in 2004 (Cook 2004). Surveys from 2003 to 2005 found 13 fish species previously undetected during studies in the 1990s, and five of these new fish species were found in 2005. These new fish detections included four freshwater species common to the Russian River watershed and one marine species.

The distribution of fish in the Estuary is, in part, based on a species preference for or tolerance to salinity (Figure 14). Fish commonly found in the lower estuary were marine and estuarine species including topsmelt (*Atherinops affinis*), surf smelt (*Hypomesus pretiosus*), staghorn sculpin (*Leptocottus armatus*), and starry flounder (*Platichthys stellatus*). The middle estuary had a broad range of salinities and a diversity of fish tolerant of these conditions. Common fish in the middle estuary included species found in the lower estuary and shiner surfperch (*Cymatogaster aggregata*), three-spine stickleback (*Gasterosteus aculeatus*), and prickly/coastrange sculpin (*Cottus asper/aleuticus*). Freshwater dependent species, such as the Sacramento sucker (*Catostomus occidentalis*) and California roach (*Hesperoleucus symmetricus*), were predominantly distributed in the upper estuary. Anadromous fish, such as steelhead (*Oncorhynchus mykiss*) and American shad (*Alosa sapidissima*), that are tolerant of both freshwater and seawater, occurred throughout the Estuary. In 2005, diversity at stations ranged from 9 species to 15 species. During 2004 and 2005, the highest diversity was 23 species at the Jenner Gulch station in 2004 (Figure 14). Stations with more species may have been due to a higher diversity of habitat features and fluctuating salinity levels that changed habitat conditions from freshwater during the spring to brackish later in the season when freshwater flows decreased. There was a higher

Table 3. Fish species captured in the Russian River estuary from 2003 to 2005.

FAMILY					2005 Captures/Seine Pull								
Scientific Name	**Common Name**	**2003**	**2004**	**2005**	**Mouth**	**Penny Island**	**Jenner Gulch**	**Patty Rock**	**Willow Creek**	**Sheep house**	**Heron Rookery**	**Austin Creek**	**Total Catch**
ATHERINIDAE													
Atherinops affinis	topsmelt	X	X		21.13	19.25	28.50	44.38	31.25	9.75	12.13	0.0	1331
Atherinops californiensis	jacksmelt	X			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
CARANGIDAE													
Trachurus symmetricus	jack mackerel	X			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
CATOSTOMIDAE													
Catostomus occidentalis	Sacramento sucker	X	X	X	0.0	0.13	0.25	0.13	8.75	1.38	8.0	37.13	446
CENTRARCHIDAE													
Lepomis cyanellus	green sunfish		X		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Lepomis macrochirus	bluegill			X	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.6	8
Micropterus salmonoides	largemouth bass			X	0.0	0.0	0.13	0.0	0.13	0.13	0.13	3.50	32
Pomoxis nigromaculatus	black crappie			X	0.0	0.0	0.0	0.0	0.0	0.0	0.13	0.0	1
CLINIDAE													
Heterostichus/Gibbonsia sp	giant/striped kelpfish			X	0.0	0.0	0.0	0.13	0.0	0.0	0.0	0.0	1
CLUPEIDAE													
Alosa sapidissima	American shad	X	X	X	0.04	0.0	0.0	0.54	0.08	1.00	0.21	1.50	81
Clupea harengus	Pacific herring	X	X	X	0.0	0.63	3.04	0.25	0.04	0.0	0.0	0.0	95
Etrumeus teres	round herring	X			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Sardinops sagax caeruleus	Pacific sardine		X		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
COTTIDAE													
Artedius lateralis	smoothhead sculpin		X		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Cottus asper/aleuticus	prickly/coastrange sculpin	X	X	X	7.63	8.79	4.13	6.54	21.42	10.21	17.13	9.21	2041
Enophrys bison	buffalo sculpin		X		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Leptocottus armatus	staghorn sculpin	X	X	X	1.08	2.17	0.0	0.58	0.54	0.0	0.0	0.0	105

FAMILY *Scientific Name*	Common Name	2003	2004	2005	2005 Captures/Seine Pull Mouth	Penny Island	Jenner Gulch	Patty Rock	Willow Creek	Sheep house	Heron Rookery	Austin Creek	Total Catch
Oligocottus maculosus	tidepool sculpin		X		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Scorpaenichthys marmoratus	cabezon		X		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Sebastes spp	rockfish (juveniles)	X	X		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
CYPRINIDAE													
Cyprinid	unidentified larvae		X	X	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.04	1
Hesperoleucus symmetricus	California roach	X	X	X	0.0	0.0	0.0	0.0	0.0	0.21	0.92	7.79	214
Lavinia exilicauda	hitch		X		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Orthodon microlepidotus	Sacramento blackfish			X	0.0	0.04	0.0	0.0	0.0	0.0	0.0	0.0	1
Ptychocheilus grandis	Sacramento pikeminnow	X	X	X	0.0	0.0	0.0	0.0	0.0	0.04	0.29	1.38	41
EMBIOTOCIDAE													
Cymatogaster aggregata	shiner surfperch	X	X	X	0.0	0.0	0.0	0.0	43.04	0.46	0.04	0.0	1045
Hysterocarpus traskii pomo	Russian River tuleperch	X	X	X	0.0	0.0	0.0	0.0	0.0	1.83	0.21	11.17	317
ENGRAULIDIDAE													
Engraulis mordax	northern anchovy	X	X		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
GASTEROSTEIDAE													
Gasterosteus aculeatus	threespine stickleback	X	X	X	0.0	0.13	0.0	0.04	7.33	5.92	8.08	1.29	547
HEXAGRAMMIDAE													
Hexagrammos sp	greenling (juv) sp		X		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Ophiodon elongatus	lingcod		X		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
LIPARIDIDAE													
Liparis sp	snailfish species		X		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Osmeridae													
Hypomesus pretiosus	surf smelt	X	X	X	1.71	2.50	0.50	0.0	0.04	0.0	0.0	0.0	114
PHOLIDIDAE													
Apodichthys flavidus	penpoint gunnel	X	X		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Pholis ornata	saddleback gunnel	X	X		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0

FAMILY *Scientific Name*	Common Name	2003	2004	2005	2005 Captures/Seine Pull								Total Catch
					Mouth	Penny Island	Jenner Gulch	Patty Rock	Willow Creek	Sheep house	Heron Rookery	Austin Creek	
PLEURONECTIDAE													
Platichthys stellatus	starry flounder	X	X	X	2.38	16.25	2.67	3.00	23.54	2.92	9.46	0.92	1467
SALMONIDAE													
Oncorrynchus kisutch	coho salmon		X	X	0.04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Oncorrynchus mykiss	steelhead	X	X	X	0.38	0.0	1.50	0.38	1.46	1.00	1.08	12.42	437
Oncorrynchus tshawytscha	Chinook salmon		X	X	0.71	0.33	0.38	1.54	0.21	0.96	0.17	0.13	106
SYNGNATHIDAE													
Syngnathus leptorhyncus (griseolineatus)	bay pipefish	X	X	X	0.0	0.0	0.13	0.08	0.04	0.08	0.0	0.0	8
TOTAL		**22**	**31**	**23**									**8440**

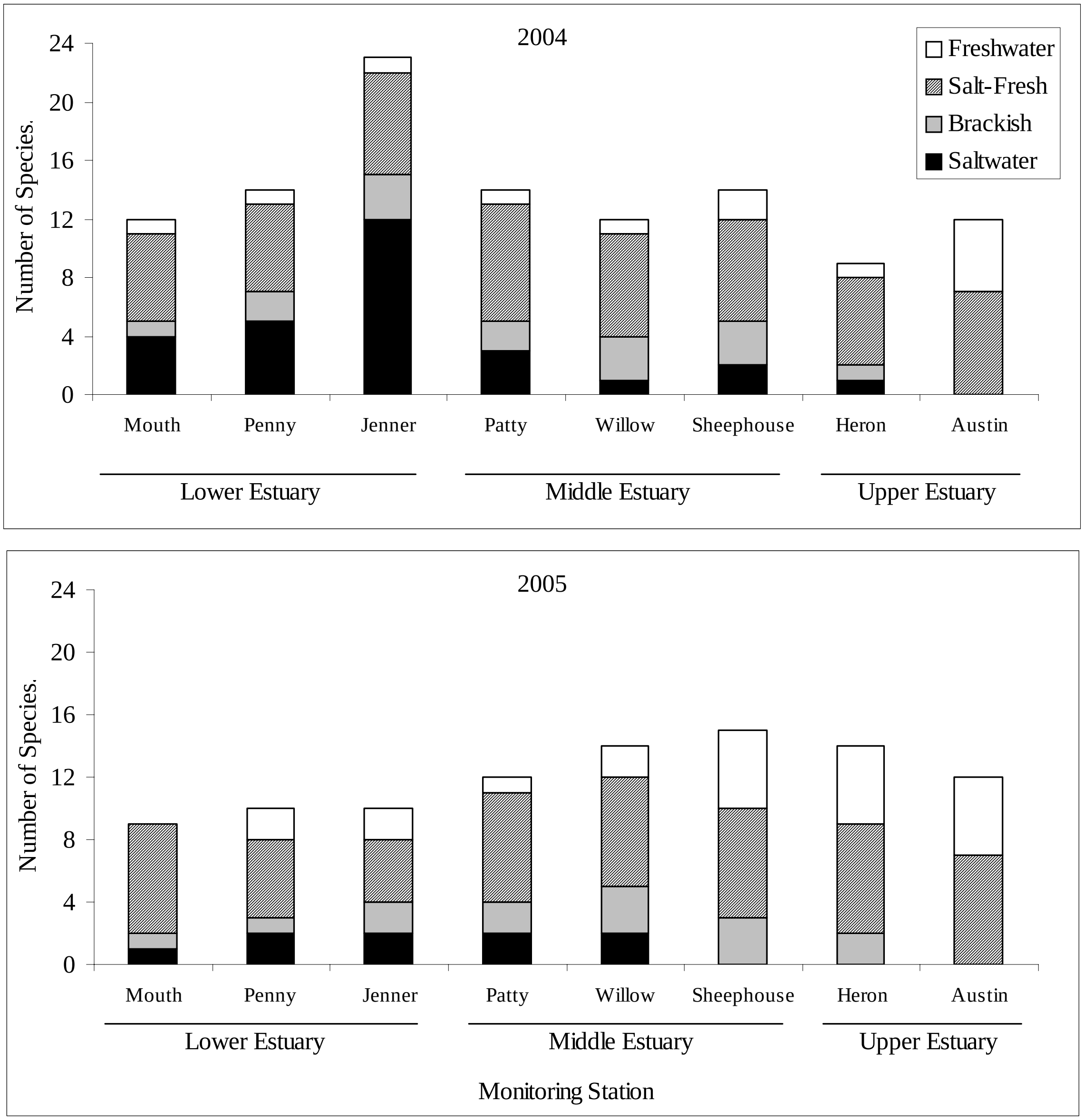


Figure 14. Distribution of fish based on tolerance to salinity in 2004 and 2005 seining in Russian River estuary. Fish groups include: Freshwater species with low tolerance to salinity; Salt-Fresh species are primarily anadromous; Brackish species complete their lifecycle in estuaries; Saltwater species are predominantly marine.

diversity of freshwater fish species throughout the Estuary and fewer marine species in 2005 than observed in 2004.

In general, there was an increase in fish abundance in an upstream direction (Figure 15). The highest relative abundance of fish was found at the Jenner Gulch station with a capture rate of 328 fish/pull in 2004 and the highest in 2005 was at Willow Creek station with 113 fish/pull (Figure 15). One possible explanation for this fish abundance pattern is the higher diversity of habitat features at these stations. High captures of fish in Jenner in 2004 may have been an anomaly because high numbers were not recorded in 2005. Habitats at Willow Creek are diverse and include mudflat, gravel bar, and emergent marsh.

The Austin Creek station consistently had relatively high fish abundance, including steelhead, during 2004 and 2005 (Figure 15; Table 3). This station was not inundated by seawater during the study and received cool freshwater from the perennial Austin Creek. Due to the lack of saline influences, this station is more characteristic of riverine habitats of the Russian River and not an estuarine environment.

Distribution and Abundance of Salmonid Species

A total of 438 steelhead and 105 Chinook salmon were captured in the Estuary in 192 seine pulls during 2005 (Table 4). Capture rates in 2005 for steelhead (2.3 fish/pull) and Chinook salmon (0.6 fish/pull) were lower than in 2004 (steelhead 2.7 fish/pull and Chinook salmon 0.9 fish/pull). Although the multi-year residence time typical of young steelhead complicates assessing growth patterns, the size of captured steelhead parr and smolts were significantly larger in 2004 than in 2005 (fork length: $\bar{x}_{2004} = 146.3$ mm, $s = 57.0$, $n = 381$; $\bar{x}_{2005} = 108.5$ mm, $s = 34.9$, $n = 437$; t-test: $t = 11.247$, df = 612, $p < 0.0001$). Only one hatchery steelhead was captured during 2005 compared to seven hatchery steelhead in 2004. The largest wild steelhead was 320 mm fork length caught at Sheephouse Creek station on 24 August 2004. The largest wild steelhead captured in 2005 was 270 mm fork length from Jenner Gulch station. Average fork lengths of Chinook salmon smolts were significantly larger in 2004 than in 2005 (2004: $\bar{x}_{2004} = 103.4$ mm, $s = 10.0$, $n = 147$; 2005: $\bar{x}_{2005} = 90.7$ mm, $s = 9.6$, $n = 105$; t-test: $t = -10.204$, df = 230, $p < 0.0001$).

Salmonid distribution in the Estuary varied by species, habitat, and season. Chinook salmon smolts were distributed throughout the Estuary with captures at every sample station, except the Heron Rookery station in 2004 (Figure 16). Chinook salmon smolt captures were highest at the River Mouth station in 2004. The highest capture in 2005 was at the Patty Rock station with 37 fish seined on the same day (Table 4). In comparison, steelhead distribution was primarily in the middle and upper reaches of the Estuary, although relatively large numbers were captured at the Jenner Gulch station (Figure 17; Table 4). The Austin Creek station consistently had the highest abundance of steelhead with >68% of all steelhead captured annually at this station. As mentioned above, Austin Creek station is entirely freshwater and is not characteristic of conditions in the Russian River estuary. The abundance of Chinook salmon peaked during early June and none were captured after July (Figure 18). Steelhead were captured throughout summer and their numbers peaked in mid-July (Figure 18).

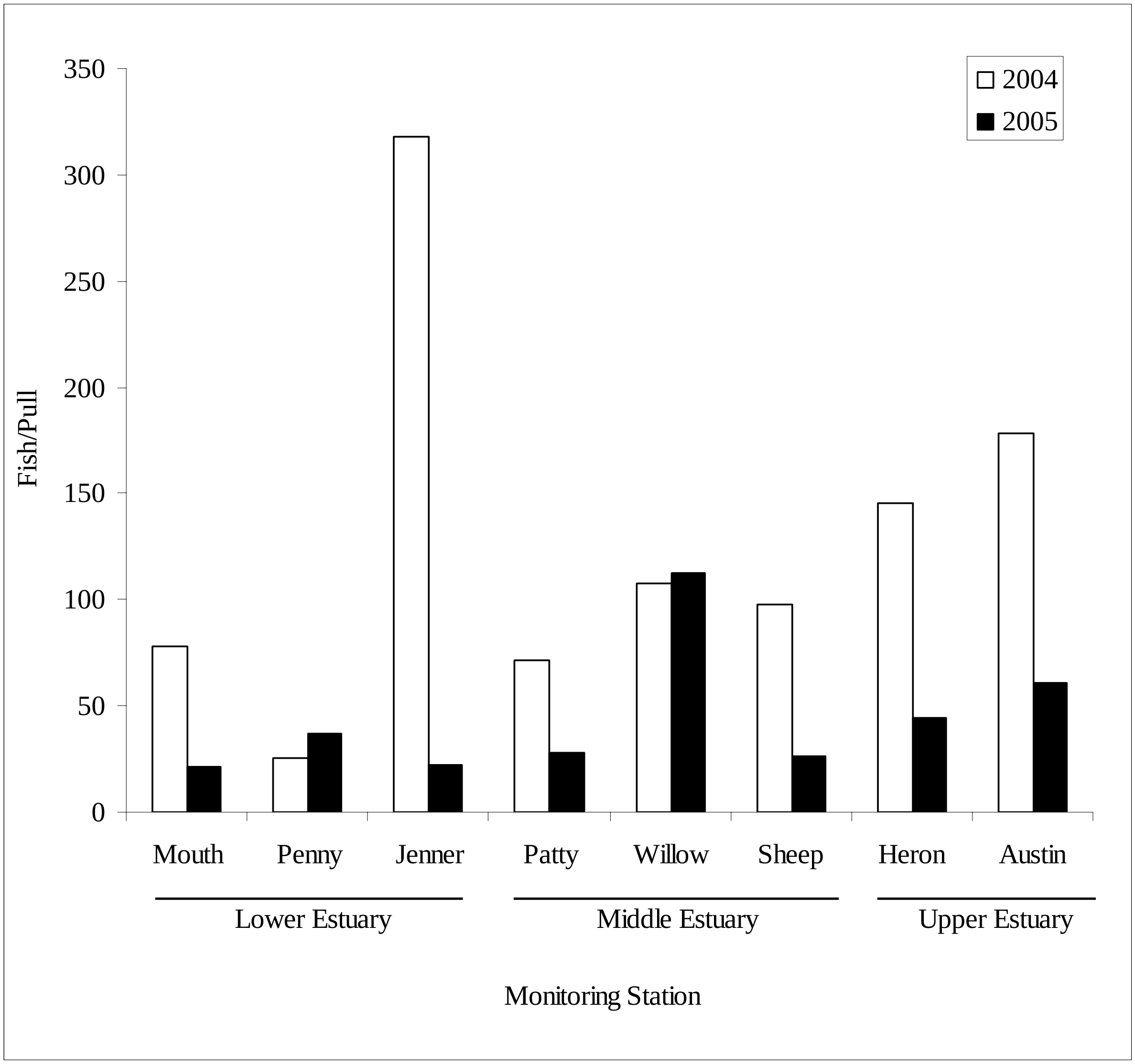


Figure 15. Mean number of fish caught per seine pull at 8 stations in 2004 and 2005 seining in Russian River estuary. Annual seine pulls at each station included 21 pulls in 2004, except the Jenner station had 24 pulls, and 24 pulls in 2005.

Table 4. Steelhead and Chinook salmon smolt captures during 2005 in the Russian River estuary. Captures are from three beach seine pulls per survey period. The station locations are shown on Figure 1.

	Survey Period								
Station	**31May-2Jun**	**20-22 Jun**	**11-14 Jul**	**25- 27 Jul**	**9-11 Aug**	**29-31 Aug**	**19-21 Sep**	**3-6 Oct**	**Total**
STEELHEAD									
Mouth	7	2	0	0	0	0	0	0	9
Penny Island	0	0	0	0	0	0	0	0	0
Jenner Gulch	1	2	3	4	21	3	1	2	37
Patty Rock	0	0	0	0	9	0	0	0	9
Willow Ck	4	3	16	8	4	0	0	0	35
Sheephouse	12	3	0	0	1	5	3	0	24
Heron Rookery	22	4	0	0	0	0	0	0	26
Austin Ck	32	15	219	18	7	0	3	4	298
TOTAL	**78**	**29**	**238**	**30**	**42**	**8**	**7**	**6**	**438**
CHINOOK SALMON									
Mouth	10	0	7	0	0	0	0	0	17
Penny Island	8	0	0	0	0	0	0	0	8
Jenner Gulch	5	2	1	0	0	0	0	0	8
Patty Rock	37	0	0	0	0	0	0	0	37
Willow Ck	5	0	0	0	0	0	0	0	5
Sheephouse	17	6	0	0	0	0	0	0	23
Heron Rookery	4	0	0	0	0	0	0	0	4
Austin Ck	2	1	0	0	0	0	0	0	3
TOTAL	**88**	**9**	**8**	**0**	**0**	**0**	**0**	**0**	**105**

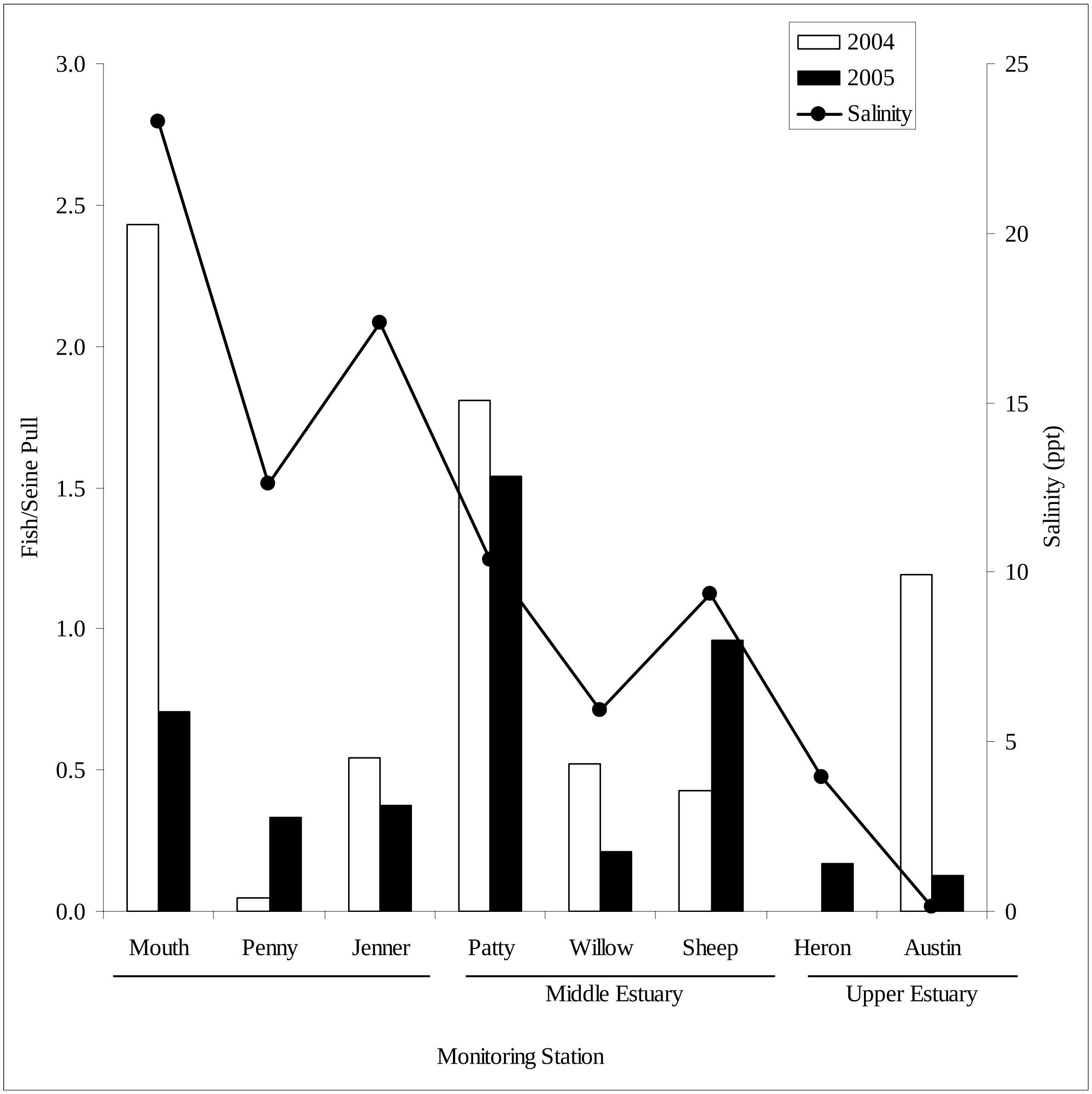


Figure 16. Distribution of Chinook salmon smolts at 8 seining stations in the Russian River estuary in 2004 and 2005. Salinities are mean values collected from the water column at each station.

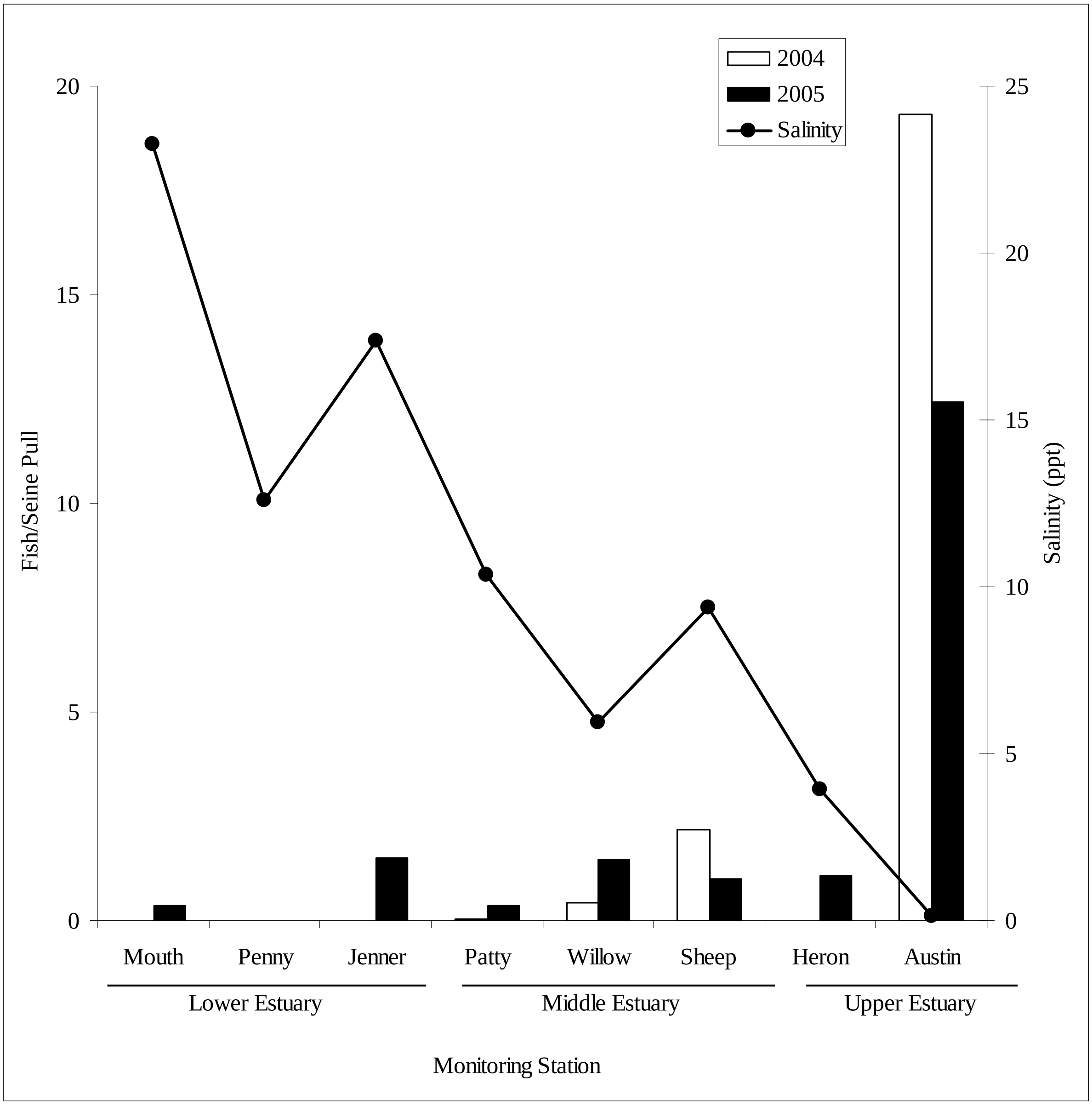
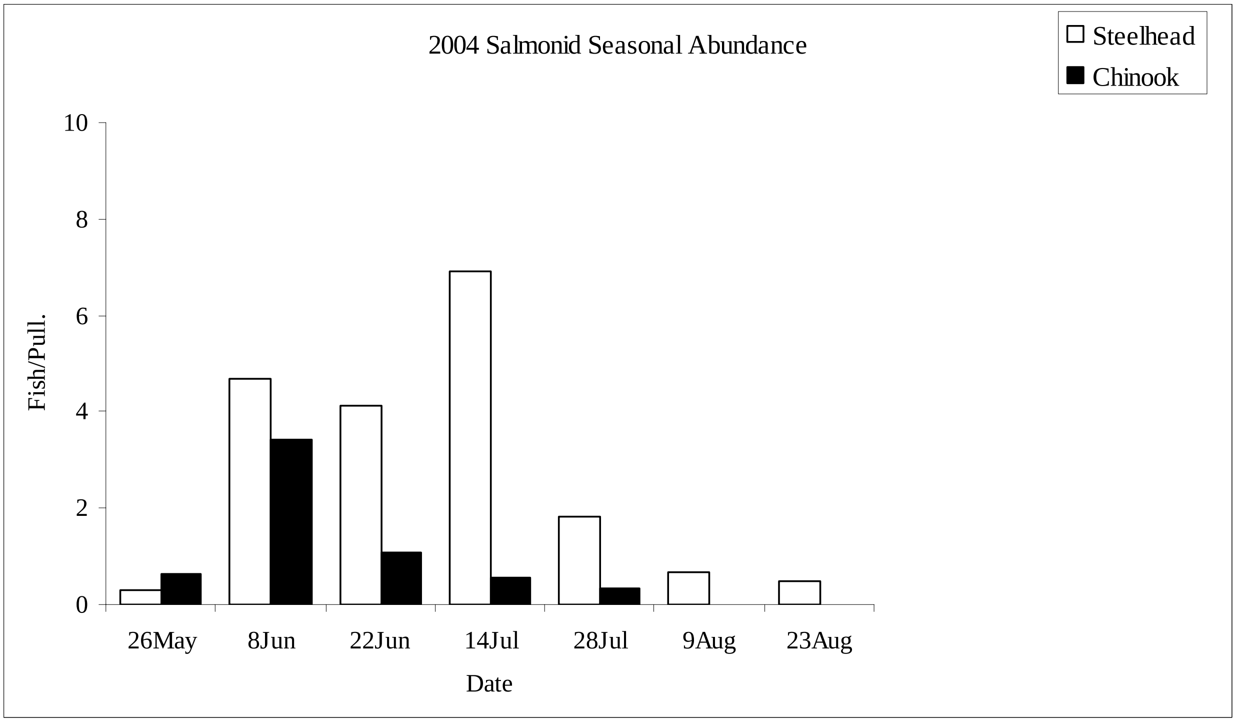


Figure 17. Distribution of steelhead at 8 seining stations in the Russian River estuary in 2004 and 2005. Salinities are mean values collected from the water column at each station.



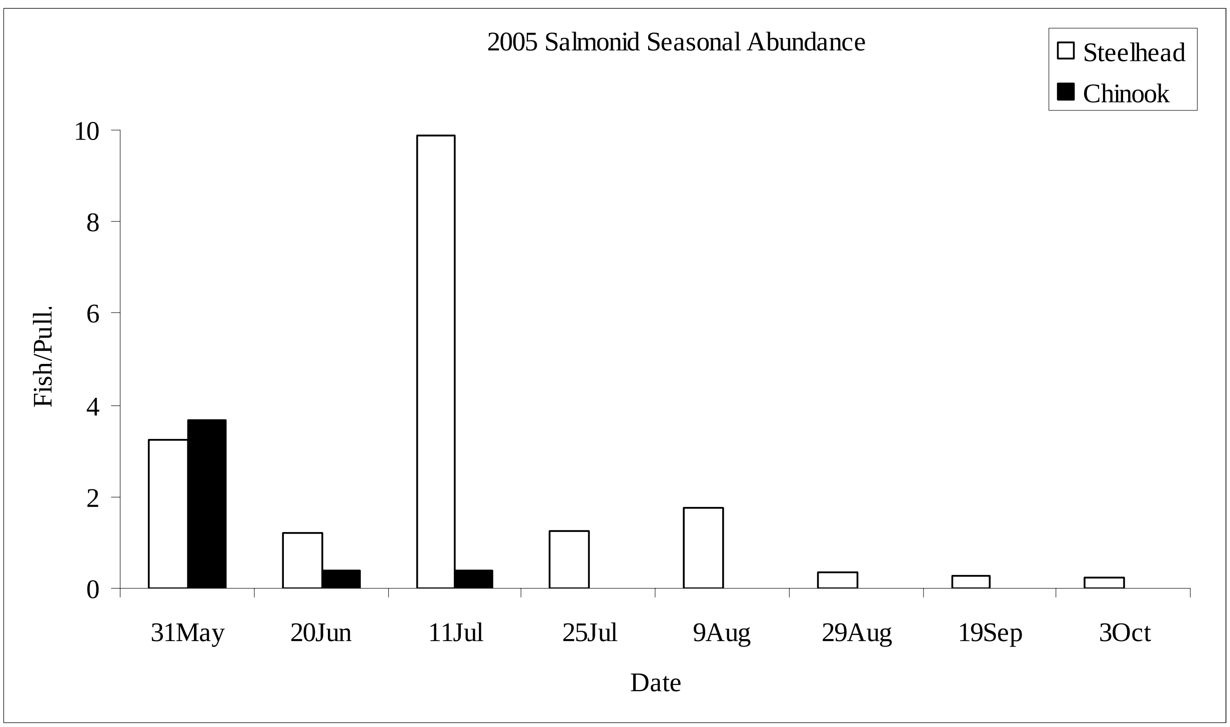


Figure 18. Seasonal abundances of steelhead and Chinook salmon during seining in the Russian River estuary in 2004 and 2005. Eight stations were sampled in the Estuary.

Macro-Invertebrate Distribution and Abundance
Three marine crab species and one freshwater crayfish species were recorded during 2 years of trapping. Only Dungeness crab (*Cancer magister*) was trapped in 2004. In 2005 three European green crabs (*Carcinus maenus*) and one hairy rock crab (*Cancer jordani*) were trapped in addition to Dungeness crab. Fish seining surveys incidentally captured red swamp crayfish (*Procambarus clarkii*) and signal crayfish (*Pacifastacus leniusculus*) at the Austin Creek station. Both crayfish species are abundant, but not native to the Russian River watershed. Bay shrimp (*Crangon stylirostris*) were detected at all fish seining stations except Austin Creek.

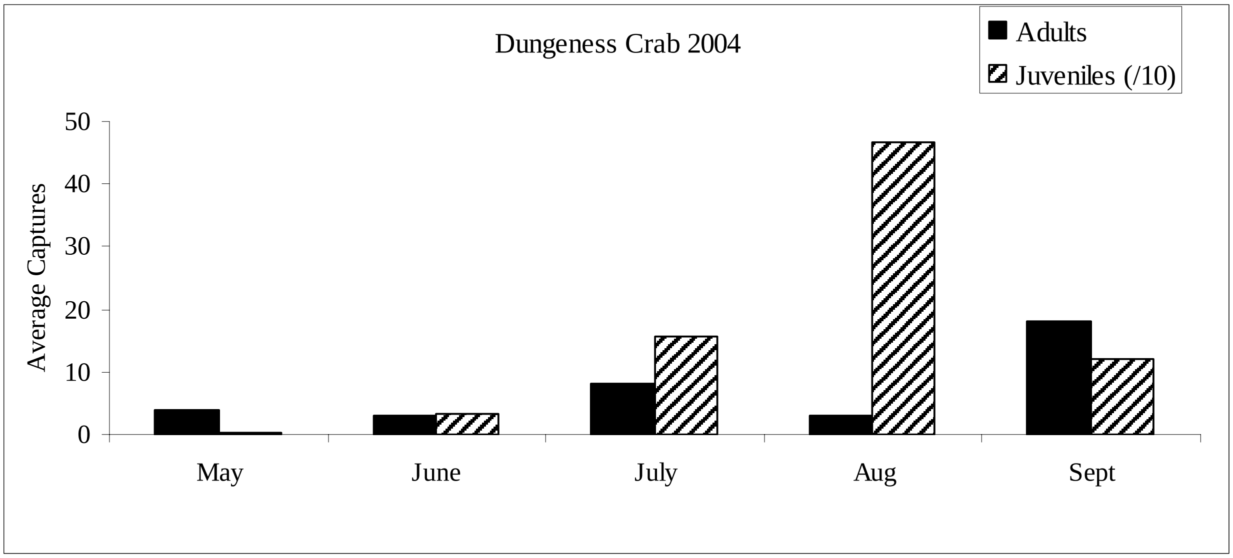
Dungeness crab captures differed substantially between 2004 and 2005 (Figure 19). A total of 26 adult Dungeness crabs were trapped in 2005 and these captures all occurred in August and September (Figure 19). In contrast, 45 adults were trapped from May to September in 2004. Although adults were absent in spring and early summer 2005, their numbers were similar during both study years in August and September. Adult sizes differed significantly between years during August and September (Carapace width: $\bar{x}_{2004} = 148.5$ mm, $s = 14.9$, $n = 24$; $\bar{x}_{2005} = 136.1$ mm, $s = 15.6$, $n = 24$; t-test: $t = 2.817$, df = 46, $p = 0.007$). No juvenile Dungeness crabs were trapped in 2005. In 2004, juvenile crabs were abundant with 1,131 captures from traps deployed from the river mouth to Bridgehaven area. Also, fish seining surveys found juvenile crabs as far upstream as the Sheephouse Creek station.

Juvenile Steelhead Residency Pilot Study

Thirty-nine of forty-two juvenile steelhead were captured, tagged, and released between 26 July and 11 August 2005. Fish were captured at 4 sites between Austin Creek and the river mouth. The capture locations were: the mouth of Austin Creek; the mouth of Willow Creek; the mouth of Jenner Gulch; and at Patty Rock (Figure 1). Three fish died following surgery and were not released. The transmitters removed from these fish were disinfected and used in subsequent releases. Most tagged fish were captured at Jenner Gulch and Willow Creek (Table 5). The mean length and weight of tagged fish was 188 mm and 94 g (Table 5). Fish captured at Patty Rock and Jenner Gulch were longer and heavier than fish captured at the 2 sites farther upstream.

Tracking
Twenty-eight of thirty-nine tagged fish were detected at least once after release by the fixed stations or manual tracking. Five of the eleven tagged fish that were never detected were tagged at Austin Creek. We were also unable to detect 1 or 2 fish from each of the other tagging locations. The remaining fish displayed behavior that may have been related to fish size, tagging location, water stage, and water quality.

Tagged fish size may have influenced the behavioral information gained from individual fish. Mean weight and length of fish that survived after tagging was 192 mm and 99 g. Fish that died following surgery or became inactive shortly after release had a mean length and weight of 161 mm and 54 g. Only 3 of 17 fish weighing under 60 g were actively moving for an extended period of time (Figure 20). Ten fish from this group were determined inactive due



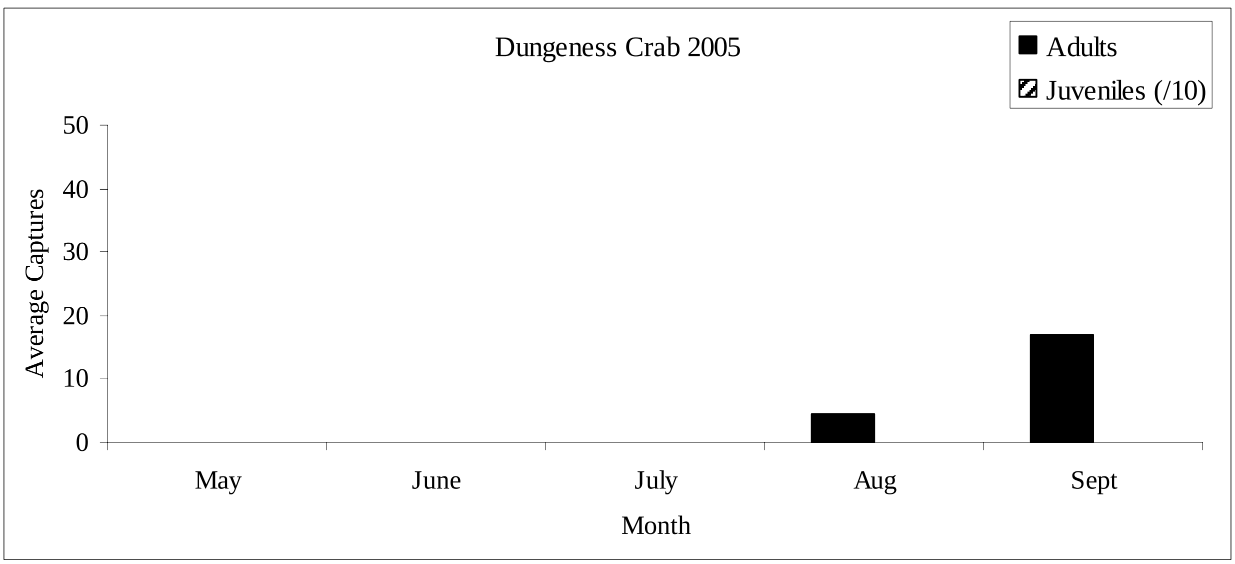


Figure 19. Monthly mean captures of Dungeness crab in the Russian River estuary in 2004 and 2005. Each of the 6 trapping stations consisted of 1 crab trap and 1 shrimp trap, baited with fish parts, and deployed for approx 24 hours. There were 8 trapping events in 2004 and 5 in 2005. Juveniles are young of the year crabs. Adults have carapace widths >90 mm. In 2005, 2 crabs with carapace widths of 67 mm and 83 mm were probably aged >1 year and were included in the Adult category.

Table 5. Summary of acoustic-tagged juvenile steelhead tracked in the Russian River estuary from 5 August to 26 November 2005. Weekly, mobile tracking was conducted from the river mouth to river kilometer (rkm) 11.7. Information includes: fish identification (transmitter #); release date and location (date and location of transmitter implantation); fork length; weight; duration of detection (time between first and last detection) [a] in days (d); and date and location of last detection.

Transmitter #	Release Date	Release Location	Date of Last Detection	Location of Last Detection	Duration of Detection (d)	Fork Length (mm)	Weight (g)
1	8/1	Austin	9/10	Austin	41[a]	180	69
2	7/25	Austin	9/10	Austin	47[a]	169	70
3	7/26	Austin	10/14	Austin	51*	157	56
4	7/26	Austin	9/10	Austin	47[a]	164	55
5	8/1	Austin	9/10	Austin	41[a]	166	56
6	8/1	Austin	10/29	Freezeout	90*	156	51
7	8/1	Austin	9/10	Austin	41[a]	183	75
8	8/11	Austin	10/14	Brown's Pool	65	194	86
Site Mean (SD)					**53 (17)**	**171 (13)**	**65 (13)**
9	8/9	Willow	8/16	Willow	8[a]	205	107.2
10	8/9	Willow	9/2	Mouth	25	163	51.2
11	8/9	Willow	9/16	Mouth	39	213	128.3
12	8/9	Willow	8/17	Mouth	8	164	54
13	8/2	Willow	8/5	Patty Rock	4	158	49.4
14	8/9	Willow	8/17	Mouth	9	164	57.2
15	8/9	Willow	8/16	Willow	8[a]	155	44.2
16	8/9	Willow	11/26	Ferry Crossing	111	170	57.9
17	8/9	Willow	11/4	Ferry Crossing	88	155	47.3
18	8/9	Willow	11/10	Duncans Mills	94	189	96.7
Site Mean (SD)					**39 (42)**	**174 (21)**	**79 (30)**
19	8/10	Patty Rock	8/16	Patty Rock	7[a]	239	185
20	8/10	Patty Rock	10/15	Mouth	67	194	98
21	8/10	Patty Rock	11/26	Willow	108	170	67
22	8/10	Patty Rock	8/15	Patty Rock	6[a]	164	57
23	8/10	Patty Rock	11/10	Duncans Mills	59	212	125
Site Mean (SD)					**49 (43)**	**196 (31)**	**106 (51)**
24	8/3	Jenner Gulch	8/5	Jenner Gulch	3	158	51
25	8/3	Jenner Gulch	9/24	Duncans Mills	53	257	192
26	8/11	Jenner Gulch	11/10	Duncans Mills	90	173	68
27	8/11	Jenner Gulch	8/16	Mouth	6	172	64
28	8/9	Jenner Gulch	9/2	Ferry Crossing	23	155	48
29	8/11	Jenner Gulch	9/16	Mouth	37	224	146
30	8/11	Jenner Gulch	10/21	Mouth	73	275	222
31	8/11	Jenner Gulch	8/17	Mouth	7[a]	160	53
32	8/11	Jenner Gulch	11/26	Sheephouse	109	242	180
33	8/11	Jenner Gulch	9/9	Mouth	30	263	222
34	8/11	Jenner Gulch	11/26	Penny Island	104*	162	49
35	8/11	Jenner Gulch	8/15	Jenner Gulch	5[a]	180	69
36	8/11	Jenner Gulch	11/26	R.R. Flat	109	185	72
37	8/11	Jenner Gulch	11/26	Patty Rock	109	228	164
38	8/11	Jenner Gulch	11/26	Jenner Gage	109*	150	46
39	8/11	Jenner Gulch	11/26	Patty Rock	108	273	267
Site Mean (SD)					**61 (45)**	**204 (47)**	**120 (72)**
TOTAL (39)					**53 (39)**	**188 (36)**	**94 (59)**

a = Not detected by fixed station or mobile tracking after release. Duration of detection calculated as the days following release until the next mobile tracking survey at location of release.
* = Determined mortality.

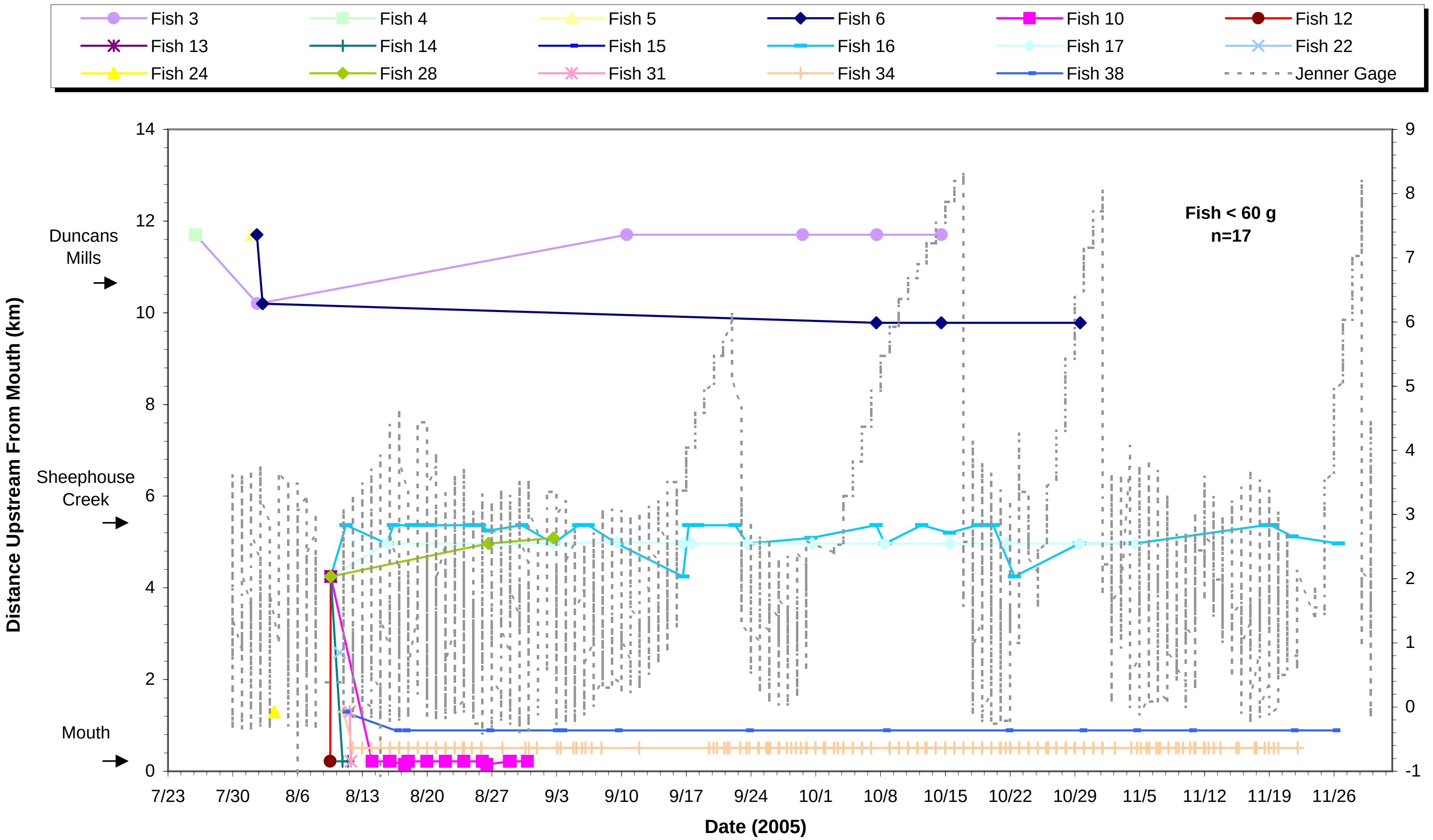


Figure 20. Locations of all juvenile steelhead weighing less than 60 grams. Fish 10, 16 and 28 were considered active fish. Fish 3, 6, 17, 34 and 38 were determined inactive during the duration of the study. Mean and standard deviation of days detected for fish less than 60 g was 44 and 42, respectively. Tracking period was between 5 August and 26 November 2005.

to lack of movement or were never detected after release. The duration of detection mean (SD) of the 7 fish detected after release by either the fixed stations or mobile tracking was 26 (41) days. In contrast, 16 of 22 fish weighing over 60 g detected by either fixed stations or mobile tracking had a duration of detection mean (SD) of 72 (33) days and moved more frequently (Figure 21).

The movements of fish tagged at Jenner Gulch, Patty Rock, and Willow Creek were variable and showed no clear trends over space or time (Figures 22 to 24). Seven of the twenty-three active fish tagged among the three sites migrated upstream to Duncans Mills. Mean (SD) length, weight, and duration of detection of fish that reached the Duncans Mills receiver was 210 (31) mm, 123 (49) g, and 75 (30) days. Additionally, 10 fish were last detected at the mouth receiver. Size and duration of detection varied greatly among these individuals. Mean (SD) length, weight, and duration of detection of possible emigrating fish was 232 (121) mm, 110 (68) g, 30 (25) days. The remaining fish tagged and released from the lower 3 sites exhibited a variety of movement patterns during the study (Figures 22 to 24). None of the fish tagged at the Austin Creek site contributed information relating to the potential use of the Estuary by juvenile steelhead (Figure 25). No fish were detected during manual tracking excursions along the lower portion of Austin Creek.

Eighty-nine water quality profiles were manually recorded during mobile tracking activities at observed fish locations throughout the duration of the study. Water quality varied greatly over space, time, and among tagged fish locations. Correlations between juvenile steelhead locations and the surrounding water quality are currently incomplete and under investigation. Additionally, there was no observed evidence indicating change in behavior during the four sandbar closures (Figures 20 to 21).

PIT tags

One hundred juvenile steelhead were tagged at the mouth of Austin Creek (Figure 26). Lengths and weights of all PIT-tagged steelhead were recorded. Mean length and weight of PIT-tagged fish was 129 mm and 30 g. Recapture efforts persisted until early October 2005. Five fish were recaptured within two weeks of initial capture and had a mean length and weight of 128 mm and 27 g (Table 6). No measurable growth had occurred.

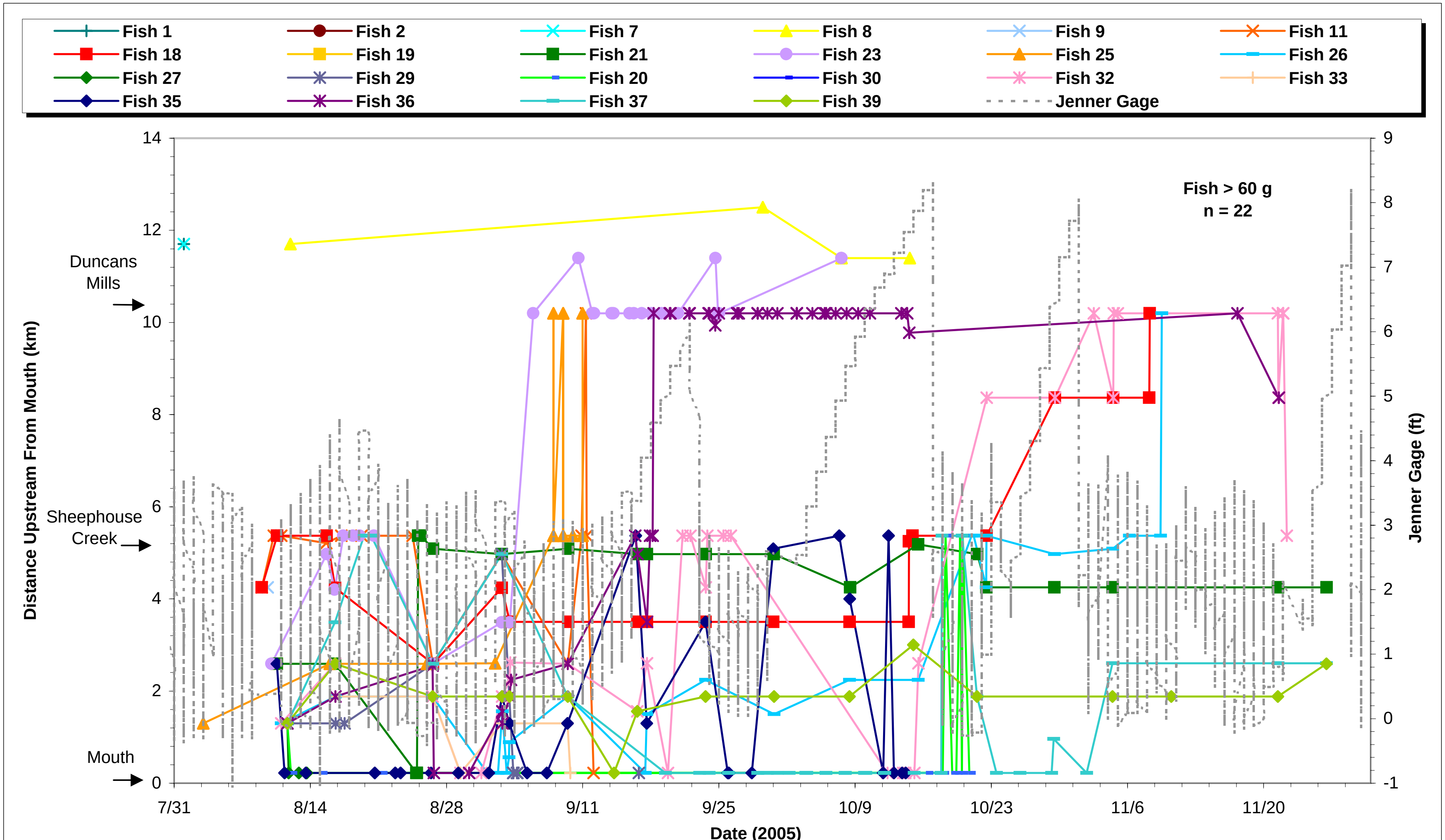


Figure 21. Locations of all juvenile steelhead weighing greater than 60 g. Fish 1, 2, 7, 9, 19 and 35 were never detected after release. Mean and standard deviation of days detected for fish greater than 60 g was 59 and 37, respectively. Tracking period was between 5 August and 26 November 2005.

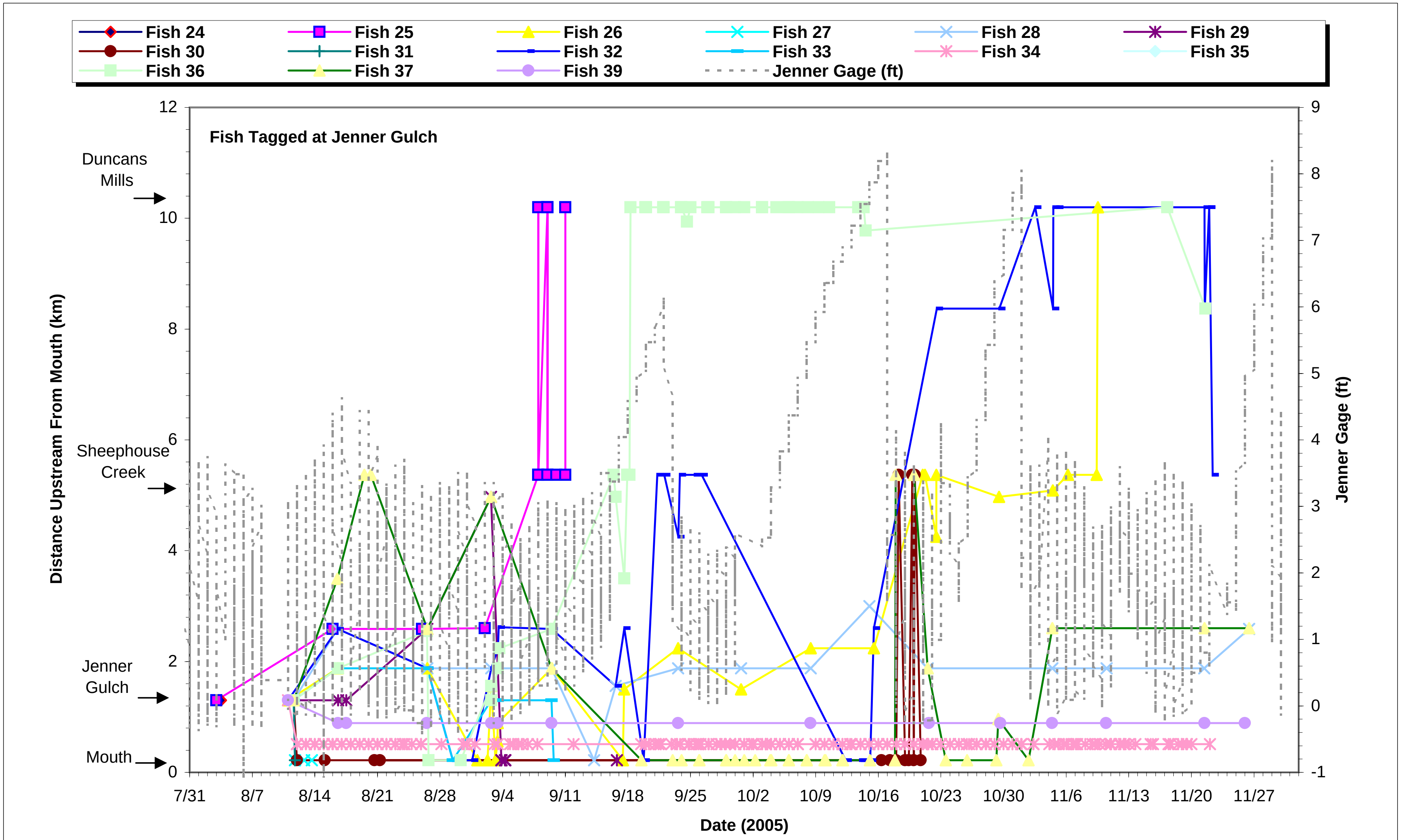


Figure 22. Locations of all juvenile steelhead released at Jenner Gulch (rkm 1.3). Fish 34 and 39 were determined inactive during the duration of the study. Tracking period was between 5 August and 26 November 2005.

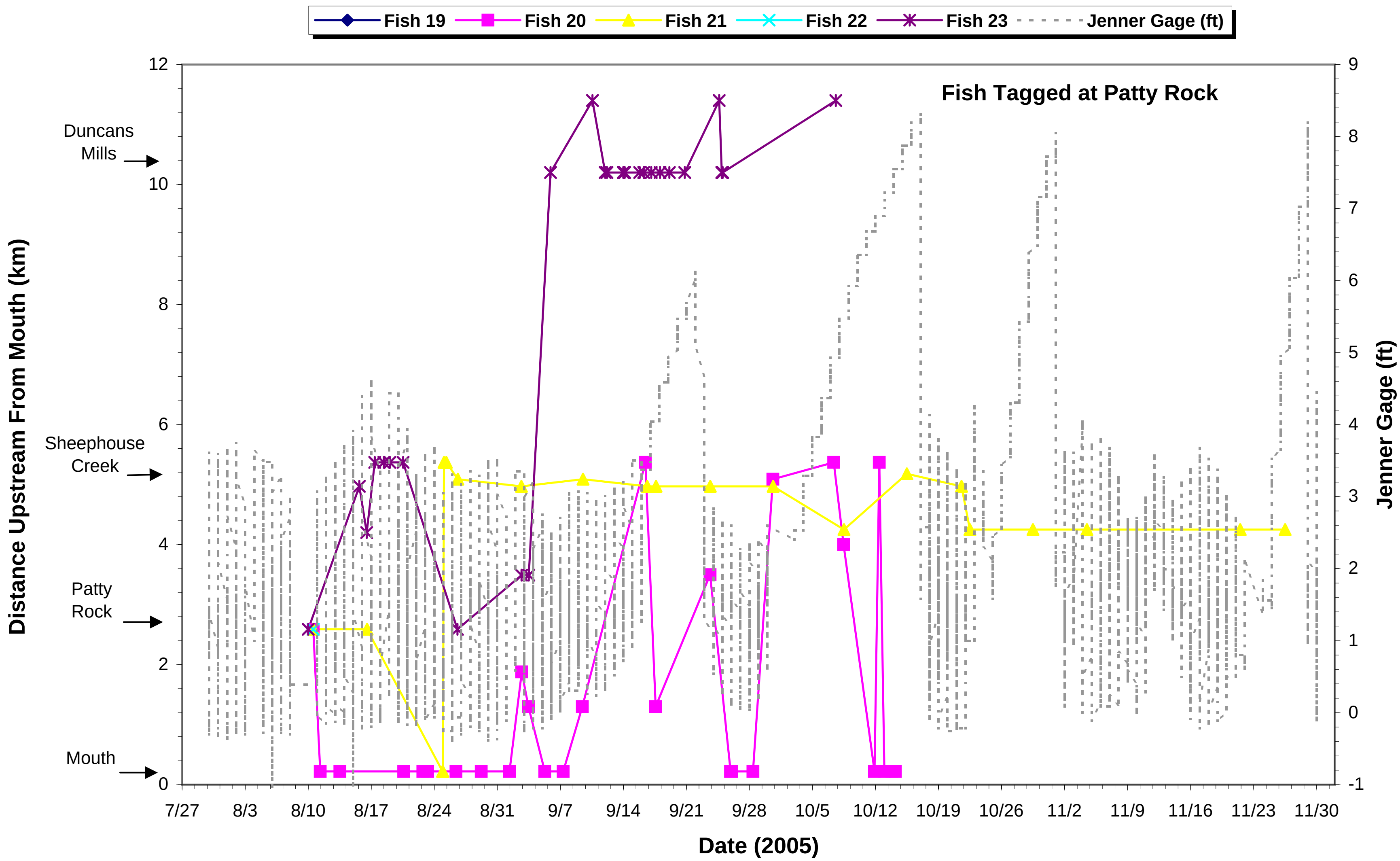


Figure 23. Locations of all juvenile steelhead released at Patty Rock (rkm 2.59). Fish 19 and 22 were never detected after release. Tracking period was between 5 August and 26 November 2005.

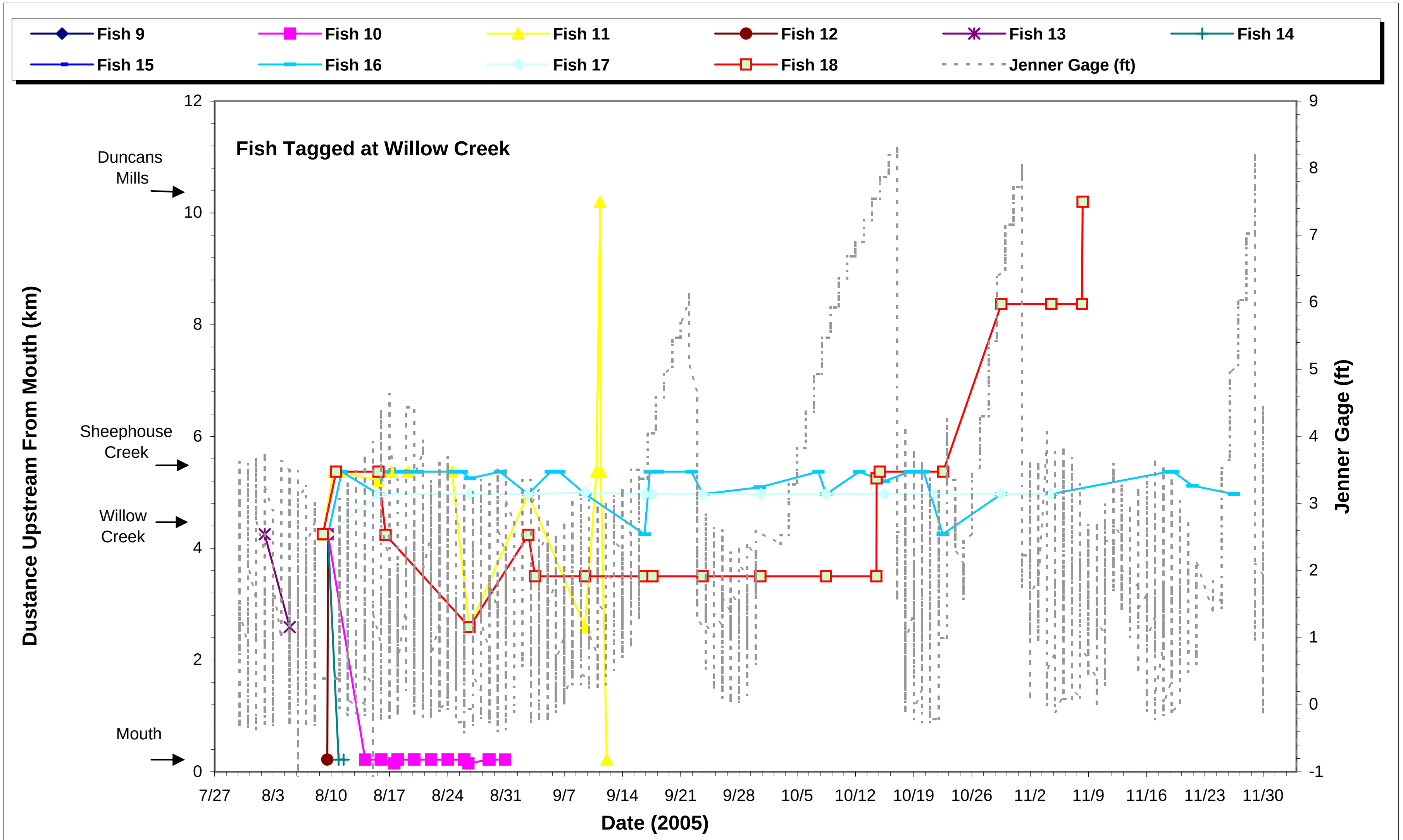


Figure 24. Locations of all juvenile steelhead released at Willow Creek (rkm 4.25). Fish 9 and 15 were never detected after release. Tracking period was between 5 August and 26 November 2005.

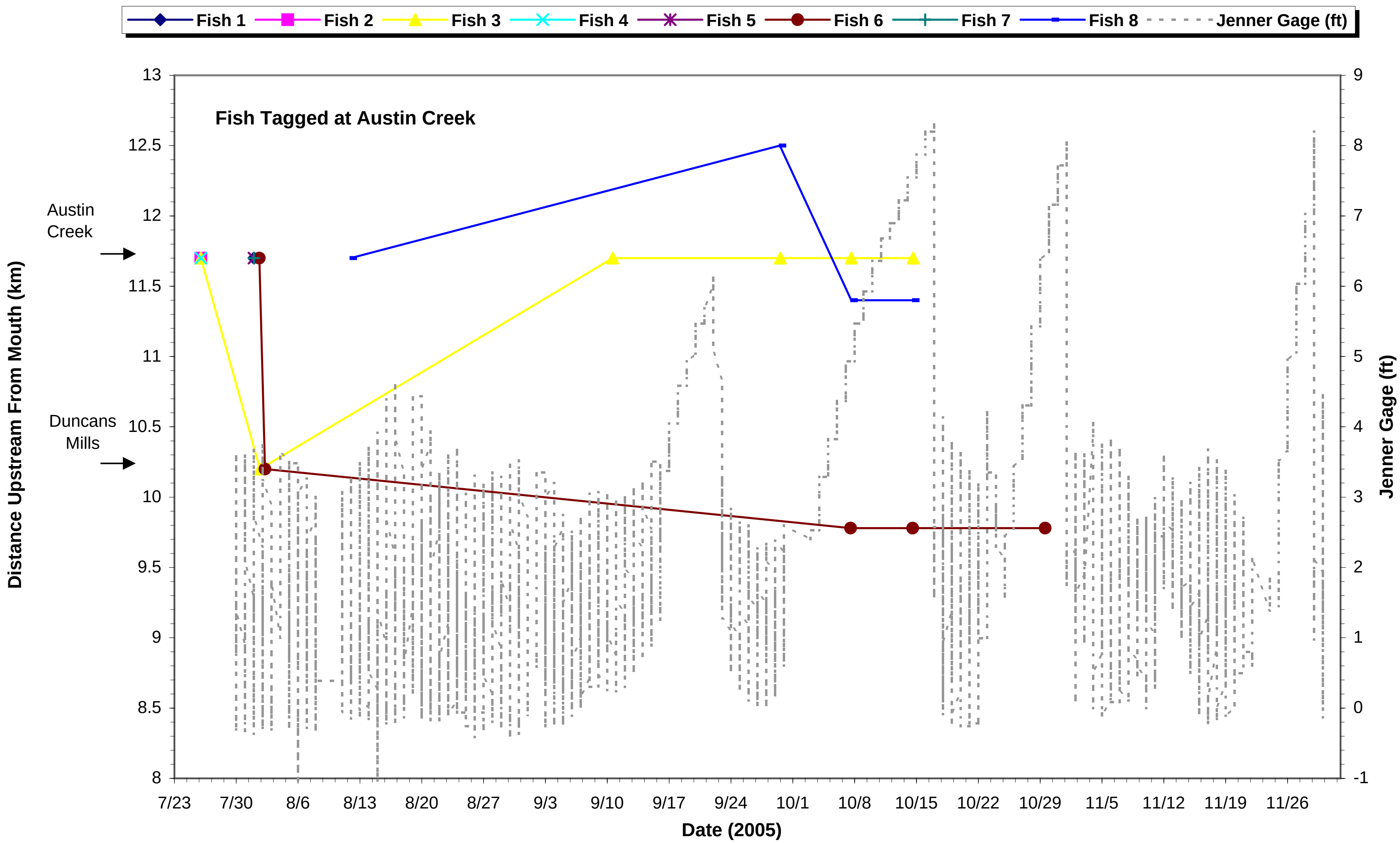


Figure 25. Locations of all juvenile steelhead released at Austin Creek (rkm 11.7). Fish 3 and 6 were determined inactive during the duration of the study. Fish 8 was the only active fish detected after release. Tracking period was between 5 August and 26 November 2005.

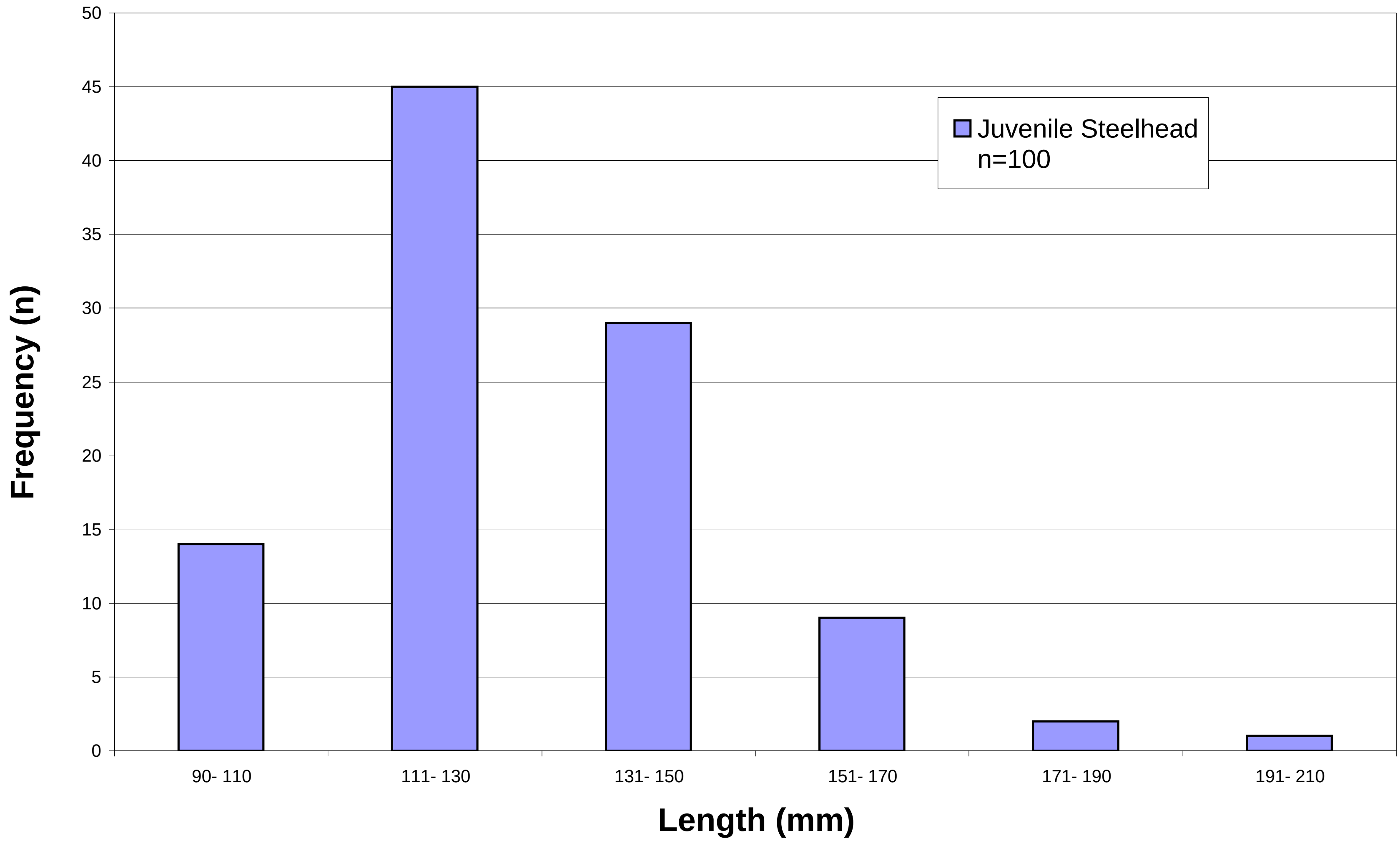


Figure 26. Length-frequency distribution of juvenile steelhead PIT tagged at the mouth of Austin Creek. Minimum length, mean length, and weight of PIT-tagged fish at the Austin Creek site was 90 mm, 129 mm and 30 g, respectively. Russian River, Sonoma County, July - August 2005.

Table 6. Summary statistics of PIT-tagged juvenile steelhead at the mouth of Austin Creek. Sampling occurred from early August to early October 2005. All recaptures took place within 2 weeks of first capture. No significant growth was documented.

	PIT-tagged Steelhead	Recaptured PIT-tagged Steelhead
Length (mm)		
N	100	5
Mean	129	128
SD	20	11
Median	129	125
Maximum	205	141
Minimum	90	114
Weight (g)		
N	100	5
Mean	30	27
SD	15	6
Median	26	25
Maximum	95	34
Minimum	8	19

Discussion

Water Quality

Overall, water quality conditions observed during the 2005 monitoring season were similar to conditions observed in 2004. The lower estuary and mid-estuary up to Bridgehaven were typically composed of a dense saltwater layer overlain by a freshwater layer approximately 1 m deep. A salt wedge occurs where saltwater and freshwater meet, whereby the denser saltwater sinks below the lighter freshwater. The salt wedge moves up and down the Estuary with the tidal cycle. Wind and channel topography also affect the exact depth and shape of the salt wedge, although the top of the wedge usually remained approximately 1 m deep.

Salinity levels were observed to fluctuate with the movement of the salt wedge. The bottom and mid-depth sondes typically had saline concentrations consistent with full strength seawater. However, the surface sondes were located at the salt wedge and fluctuated from freshwater to saline and back to fresh as the salt wedge moved through the Estuary. Temporary decreases in salinity concentrations occurred at most sondes during estuary closure and following sandbar breaching events. Decreases observed during estuary closure may be evidence of the freshwater inflow pushing the denser saltwater out of the Estuary through the sandbar. Once the river had been reopened, the downstream movement of the salt wedge was likely attributable to the initial flush of water out of the Estuary. However, this flush was observed to be temporary with salinity concentrations typically recovering to pre-closure levels as the salt wedge migrated back upstream during subsequent high tides.

There were periods of time during the monitoring season when salinity concentrations were observed to be greater at the mid-depth sonde than at the bottom sonde at a given station. This was observed to occur at all 3 stations during various times of sampling. Typically the bottom sonde should record an equal or higher salinity concentration than the mid-depth sonde, since increasing salinity also increases water's density. However, there may be other variables at play that allow this relationship to reverse.

Most of the time, the differences were observed to be within 1 to 2 ppt, which could be attributable to natural variations caused by movement of the salt wedge. Differences in concentration were also observed to be quite significant at times. The most significant differences between sondes, as much as 15 ppt less at the bottom sonde than at the mid-depth sonde, typically occurred as short spikes lasting a few hours to less than a day. Although the equipment appeared to be functioning properly, there is a possibility of a temporary malfunction of the equipment, possibly compounded by calibration differences and conditions in the water column itself.

The subject data will need to be analyzed further to see if the equipment was indeed malfunctioning or whether there is an environmental influence contributing to this phenomenon. In the future, the dataset may be modified as further research on the subject is completed. However, the data included herein should be considered sufficient for the purposes of describing general background conditions for this report.

Temperature stratification coincided with the presence of the salt wedge, as the saltwater was observed to be significantly colder than the freshwater. The ocean supplies saltwater to the Estuary during each high tide cycle that is typically around 10 to 12 degrees C, whereas the river and its tributaries supply freshwater flows from warm interior valleys and canyons where water temperatures can be as high as 25 degrees C. Surface sonde temperatures were observed to have the greatest degree of fluctuation due to their location at the saltwater-freshwater interface. However, temperatures were also observed to exhibit diel fluctuations based on the heating and cooling effects of night and day, as well as longer-term seasonal heating and cooling events.

Dissolved oxygen concentrations were observed to fluctuate significantly during the monitoring season at all stations. These fluctuations were not necessarily associated with tidal cycles nor were they on a diurnal cycle. Supersaturation and anoxic events were observed, with prolonged anoxic events occurring at the bottom sondes through the duration of estuary closure. Based on these observations, it is likely that there are both oxygen production and oxygen reduction factors present in the Estuary.

Most hydrogen ion (pH) readings were observed to be slightly basic and fairly consistent among all stations at all depths. However, the bottom sondes experienced slight decreases in pH that generally coincided with decreases in D.O. concentrations, especially during estuary closure events when the water at the bottom sondes would become anoxic. Following the Estuary reopening, the pH levels would typically return to pre-closure levels.

Fisheries

The results of the 2003 to 2005 studies found a total of 40 fish species from marine, estuarine, and riverine environments. The detection of five new fish species in 2005 previously undetected during past field studies (Cook 2004 and 2005; Sonoma County Water Agency and Merritt Smith Consulting 2001) suggests that the fish fauna of the Estuary may be understudied. The distribution of species was influenced by the salinity gradient in the Estuary that is typically seawater near the mouth of the Russian River and freshwater at the upstream end. Exceptions to this distribution pattern were anadromous fish that occurred throughout the Estuary regardless of salinity levels. Four new species captured in 2005 are restricted to freshwater habitats and probably originated from the Russian River upstream of the Estuary. These fish probably dispersed to the Estuary due to an unusually large rain event in late May that increased flows and freshwater conditions in the Estuary during the early sample season.

The distribution and abundance of salmonids rearing in the Estuary differed spatially, temporally, and by species. Chinook salmon smolts occurred throughout the Estuary in all habitat types sampled; although they were more frequently found in non-tributary habitats. Chinook salmon smolts spent less than half the summer rearing in the Estuary. Steelhead were found during the entire summer and were restricted to the middle and upper reaches of the Estuary. Although there are several factors influencing fish distribution, steelhead were more frequently found at the confluences with tributaries. A possible explanation for this distribution is that creek mouths are sources of cool, freshwater that steelhead use as refuges. However, growth rates and habitat use of salmonids in the Estuary should be further studied to assess trends.

Macro-invertebrates

The 2004 data indicated that the Estuary is a nursery for juvenile Dungeness crabs; however, no juveniles were caught in 2005. This bust or boom pattern may be a result of atypical winter ocean temperatures and currents in 2005. These ocean conditions probably affected larval Dungeness crab survival and migration to inshore areas and estuaries. A similar pattern occurred in the San Francisco Bay, which is an important nursery for young Dungeness crab, as no juveniles were recorded in 2005 (Kathy Hieb, California Department of Fish and Game, pers. comm.).

The European green crab is a non-native species that was first introduced to the San Francisco Bay in the 1980s and since has invaded other Pacific Coast estuaries. This crab has decimated fisheries on the east coast. The capture of 3 individuals in 2005 is the first known occurrence in the Estuary and may become established with unknown consequences to the native fishery. Further studies of the abundance and distribution of this species in the Estuary would be helpful in managing this species.

Juvenile Steelhead Residency Pilot Study

We successfully tracked fish for over 100 days and gained insight to juvenile steelhead utilization of the Russian River estuary. Migratory behavior of tagged juvenile steelhead was highly variable among individuals, but preliminary results suggest trends that will help refine questions for future studies.

We gained less information about smaller fish (<60 g) than larger fish (>60 g) because short-term mortality was higher, movement was less frequent, and tracking durations were shorter. We believe the behavior of smaller fish was affected by the size and weight of the transmitters. The stress of capture, handling, and implantation of a relatively large transmitter may have increased the susceptibility of these smaller fish to predators. In 2006, we plan to use a combination of smaller and larger tags to avoid high tag weight to fish weight ratios. Using smaller tags will limit the tracking duration in some fish because tag size and weight are functions of battery size and tag life.

The area between Jenner Gulch and Sheephouse Creek was highly utilized during the early part of the study. Schooling by tagged fish was observed below Patty Rock on multiple occasions. As the season progressed, we expected most fish to emigrate to the ocean. Some evidence suggests that this occurred, but only 28% of the fish were last detected at the mouth receiver. Because seals and pelicans congregated near the mouth receiver station throughout the study period, we could not determine if fish last detected at that site had emigrated or were consumed.

While movement between Jenner Gulch and Sheephouse Creek was common, fewer fish were detected in the 5-km reach from Sheephouse Creek to Duncan's Mills. Only 2 fish resided near the Sheephouse Creek receiver for extended periods of time and the 7 fish that passed Sheephouse Creek and were detected at Duncan's Mills appeared to move rapidly. We plan to conduct more frequent mobile tracking and collect additional water quality data in 2006 to elucidate patterns of fish behavior in the upper estuary.

Preferred water quality by juvenile steelhead in the Russian River estuary remains a major question. Based on our mobile tracking surveys, tagged steelhead were detected in areas with variable salinity, temperature, and D.O. Without knowing where fish reside in the water column, it is extremely difficult to predict preferred water quality conditions. Future micro-movement mobile tracking surveys with concurrent localized water quality measurements will hopefully provide further insight to juvenile steelhead preferred habitat in the Russian River estuary.

Changes to Monitoring in 2006

We plan to institute changes to the Russian River Estuary Sandbar Breaching Monitoring Plan to improve assessment of habitat parameters that affect salmonid use of the Estuary. The changes do not significantly alter previous methods used; we anticipate that these changes will refine our monitoring methods to detect trends of salmonid behavior in the Estuary.

Water Quality

Water quality monitoring stations near Freezeout and Sheephouse creeks will be added in 2006. The stations will provide water quality data in the upper estuary and additional data in the middle reach of the Estuary. The Freezeout Creek station will require a single datasonde because of the shallow depths in this reach of the river. The Sheephouse Creek station will be composed of 2 sondes due to the greater depths at this location. The new monitoring stations, as well as the existing stations, will be operated using the methodologies described in this report.

Fisheries

Methods for the Russian River estuary fisheries study will be modified and refined from previous years to further assess the distribution and relative abundance of species. Three survey approaches will be implemented in 2006.

<u>Interval Fisheries Surveys</u>

Interval seining employed during 2004 and 2005 would continue in 2006. Seining will follow the methodologies previously described in this report. Stations will be monitored approximately every 3 weeks from May to October 2006.

Eight seining stations are located throughout the Estuary in a variety of habitat types based on substrate type (i.e., mud, sand, and gravel), depth, and tidal and creek tributary influences (Figure 1). These stations were identified during 2003 studies (Cook 2004). The Austin Creek station will be discontinued in 2006 because conditions did not exhibit estuarine characteristics during the previous two monitoring seasons. A station at Freezeout Creek, located approximately 2 km downstream from Austin Creek, will be added. Habitat characteristics at the Freezeout Creek seining stations are as follows:

- Freezeout Creek - located at the confluence with a perennial creek, gravel substrate with a moderate slope, freshwater influence from the creek.

Habitat characteristics for the remaining stations were described previously in this report.

<u>Intensive Fisheries Surveys</u>
Our fish seining surveys in the Estuary indicated a sporadic distribution of many fish species. This pattern is affected by the schooling behavior of some fish and fluctuations in habitat conditions in the Estuary due to tidal cycles. To further assess habitat use and distribution of salmonids, selected seining stations will be intensively surveyed during a 3- to 4-day period. These stations will be surveyed monthly throughout the summer. The stations will be located in the lower and middle estuary where tidal fluctuations are the strongest. Each station will be sampled with multiple seine pulls during each sample period. The timing of each sample period will be randomly selected based on tidal cycle (e.g., incoming tide, slack tide, outgoing tide). Stream gages will be placed at each station and depth recorded at the beginning and end of each sample period to assess tidal phase.

Water quality data will be collected during each sampling event. A hand-held YSI meter with a probe at the end of a cable will be used to obtain temperature (degrees C), salinity (ppt), and D.O. (mg/l). Water quality will be recorded prior to and following seining at 0.5 m (1.6 ft) depth intervals at the approximate center of the seine sample area. A Secchi disc will be used to measure turbidity.

<u>Exploratory Surveys</u>
Several fish survey techniques will be employed to further assess the distribution of fish in the Estuary. Seining can be very effective in sampling fish, but is less effective in areas with submerged trees and rocks. Other survey techniques may prove more effective in snag-prone areas, including direct observation (snorkel), gill net, and electrofishing. These techniques will be used primarily in the upper estuary where seining is difficult due to submerged trees. The upper estuary has better water visibility for snorkeling and has more freshwater, which is required for electrofishing. Fish species, habitat characteristics, and water quality will be recorded at each sample site.

Macro-invertebrates
Macro-invertebrates will be surveyed using the methods described previously in this report. Traps will be deployed monthly from July to September in 2006, rather than every 3 weeks as in 2005.

Juvenile Steelhead Residency Pilot Study
As discussed previously, we believe that the behavior of smaller steelhead (<60 g) was affected by the size and weight of the transmitters. A combination of smaller and larger tags will be used in 2006 to avoid high tag weight to fish weight ratios. Smaller tags will reduce

the tracking duration in some fish because battery size and life are functions of tag size. Mobile tracking will be conducted more frequently and additional water quality information will be collected in the upper estuary to elucidate patterns of fish behavior.

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